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Evaluation of primocane-fruiting raspberry (*Rubus idaeus* L.) cultivars in Estonian climatic conditions

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Abstract. During the three-year period from 2022 to 2024, five primocane-fruiting raspberry cultivars (‘Delniwa’, ‘Enrosadira’, ‘Jantar’, ‘Poemat’, ‘Polka’) were evaluated at the Polli Horticultural Research Centre of the Estonian University of Life Sciences, situated in southern Estonia. This study aimed to assess the traits of yield and fruit quality indicators of these selected cultivars, as well as their resistance to abiotic stress factors (temperature fluctuations and precipitation variability) and their adaptability to Estonian climatic conditions. As a result of the study, the most suitable raspberry cultivar for cultivation in Estonian conditions was identified among these cultivars. The study revealed significant differences between cultivars. The Polish cultivar ‘Poemat’ performed most consistently and proved to be well-adapted to Estonia’s climate. In contrast, the Italian cultivar ‘Enrosadira’ had the most fluctuating yields year-to-year, implying it’s more sensitive to varying weather conditions. The low yield of ‘Polka’ in the first year of observation, which constantly decreased in successive years, showed that this cultivar is not suitable for the Estonian climate conditions. Among the cultivars tested, ‘Delniwa’ from Poland showed the highest ratio of total soluble solids to total acids in juice, indicating the best taste characteristics. The study highlights the cultivar ‘Poemat’ among the evaluated raspberry cultivars as the most promising for Estonian growers due to its stable yield and good adaptability to climatic conditions. The study results provide practical knowledge for selecting parent cultivar plants in raspberry breeding and planning plantations in the Baltic region.
Key words: climate adaptation, fruit quality, soluble solids, total acids, yield.

Introduction

Raspberries (*Rubus idaeus* L.) are a member of the rose family and belong to the genus *Rubus*, which includes 12 subgenera, hundreds of species and thousands of cultivars (Fotirić Akšić *et al.*, 2022). Mount Ida in ancient Greece (now located in modern-day Turkey) is considered the origin of the raspberry. Swedish biologist Carl Linnaeus also used the name of this place of origin when he gave the raspberry the Latin name *Rubus idaeus* (Hendrick, 1925).

In 2023, raspberries were grown on more than 121,000 hectares worldwide, with a total annual harvest of 959,776 tonnes. The largest raspberry producers in the world were the Russian Federation, with ~ 219,338 tonnes, Mexico, with ~ 190,411 tonnes and Serbia, with ~ 98,674 tonnes. In Estonia, raspberries were grown on 100 hectares in 2022, resulting in a total harvest of 100 tonnes, which yielded 1,000 kg ha^{-1}. In 2023, raspberries were grown on 110 hectares, and the total harvest was 70 tonnes, yielding 636 kg ha^{-1}. In 2023 the countries with the world’s highest raspberry yields were Portugal, at 21,226 kg ha^{-1}, Mexico, at 18,540 kg ha^{-1}, and Switzerland, at 16,456 kg ha^{-1} (*FAOSTAT*, 2025).

A distinction is made between primocane-fruiting and floricane-fruiting raspberries. Primocane-fruiting raspberries begin to bear fruit in the fall of their first year, while floricane-fruiting raspberries only bear fruit in the second year (Kim *et al.*, 2016). Primocane raspberries have the advantage over floricane raspberries that their canes are free of winter damage and, in favourable autumn weather, the harvest time for the fruit can be from late summer to late autumn. Although primocane-fruiting plants can bear fruit in the second year, double fruiting is practised only in some warmer regions such as California and Chile, where there is a short cold period (Pritts, 2008).

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The growth and ripening of raspberries are directly affected by weather conditions - sunlight, temperature, wind, and precipitation (Fotirić Akšić *et al*., 2022; Privé *et al.,* 1993; Sullivan & Privé, 2001). Hot summers can lead to smaller fruit and reduced yields (Aguilar *et al*., 2025). High humidity (>80%) and high pre-harvest rainfall are viewed as significant risk factors for damage to raspberry yields (Jarvis, 1962; Kozhar & Peever, 2018).

Red raspberries are a rich source of minerals, vitamins, fatty acids, and dietary fibre, and contain a broad spectrum of polyphenolic phytochemicals, including flavonoids, phenolic acids and tannins. The specific beneficial phytochemicals found in raspberries are known for their potential to improve human health by reducing the risk of cardiovascular diseases, diabetes, chronic diseases and certain types of cancer (Rao & Snyder, 2010). The nutrient content of raspberries depends mainly on the ripeness of the fruit, soil characteristics, and weather conditions, but the cultivar (genotype) is considered the most important influence. (Fotirić Akšić *et al*., 2022; Mazur *et al*., 2014; Mazur *et al*., 2014).

The conducted research aimed to evaluate the yield, fruit quality indicators and resistance to abiotic stress factors (temperature fluctuations and precipitation variability) of five raspberry varieties ('Delniwa', 'Enrosadira', 'Jantar', 'Poemat', 'Polka') in Estonian climatic conditions in order to identify the most suitable variety for cultivation in Estonia, as well as to provide practical recommendations for the selection and breeding of raspberry varieties in the Baltic region. Such research is important in ensuring consistent raspberry production and high-quality harvests.

Materials and Methods

The research was carried out from 2022 to 2024 in Viljandi County at the raspberry collection garden of the Polli Horticultural Research Centre of the Estonian University of Life Sciences (58°7′44″ N, 25°32′16″ E). The testing plantation was established in the spring of 2022, with five primocane-fruiting raspberry cultivars: 'Delniwa' (POL), 'Enrosadira' (ITA), 'Jantar' (POL), 'Poemat' (POL) and 'Polka' (POL) in four replicates with ten plants in each replicate. The distance between plants in the row was 0.5 m, 1 m between replicates, and 3.5 m between rows. The established plantation was surrounded by raspberry and blackcurrant plantations, and the western side of the plantation was sheltered from the wind by linden trees. Raspberry pruning, which involves cutting off all the canes of the raspberry bush, was carried out every year in early spring. No summer pruning, branch thinning or pruning, which could have affected the yield of raspberries, was carried out. The soil in the plantation was soddy-podzolic clay loam. The experimental area was fertilised through a drip irrigation system with YaraTera Kristalon Red 12-12-36 + microelements 0.1% irrigation solution. Irrigation was carried out as needed from June to September.

The weather data for the experimental years were collected from the weather observation point of the Polli Horticultural Research Centre from 1 September 2022, to 30 November 2024. Figures 1–3 display the weather graphs for each test year from March to the end of the year. The top graph of each figure displays the average daily temperature and the daily temperature range. The bottom graph displays the precipitation and relative humidity for the given period, plotted by day. The graphs in Figure 1 illustrate the weather from

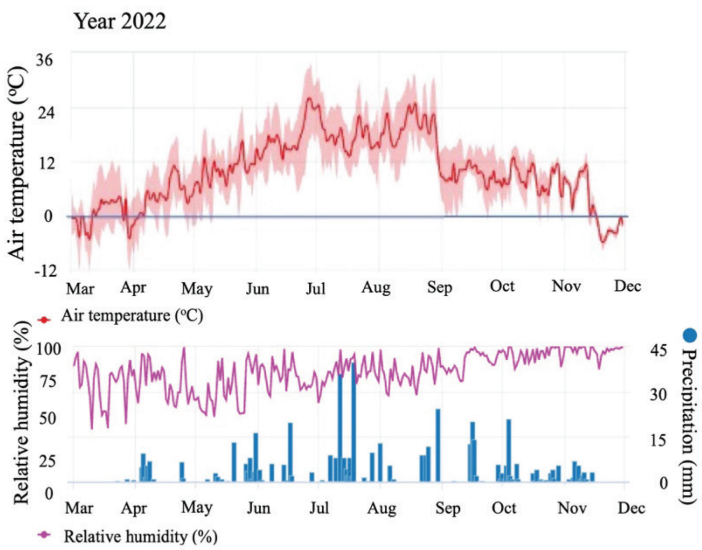

Figure 1. The weather data graph for March–December.

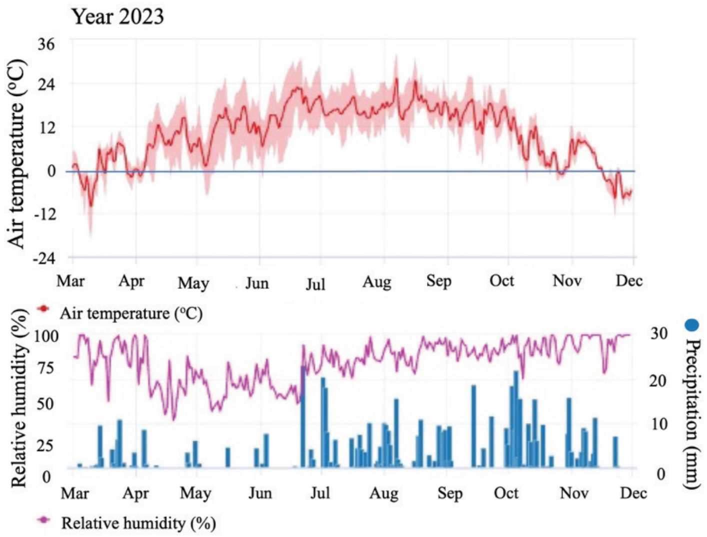

Figure 2. The weather data graph for March–December.

March to December 2022. In 2022, the temperature was 0.5 °C higher than the long-term average. The second quarter was dry and warm. The average air temperature was 0.3 °C above the long-term average. The average relative humidity for the second quarter was 73.6% and the total precipitation for the three months reached 145 mm. The average temperature for the third quarter matched the long-term average; the relative humidity was 83.7% and the total precipitation was 270 mm. August was warm, with an average monthly temperature of 19.4 °C and low precipitation (76 mm). September became sharply cooler with an average monthly temperature of only 8.9 °C, and from 3 September onwards, there were slight night frosts of -0.5 °C. The average temperature for the month was 2.7 °C lower than the long-term average. Precipitation for September was low at 60 mm. The average temperature for October was 8.1 °C, which was 2.2 °C higher than the long-term average, but the amount of precipitation remained low (60 mm). On 14 November, night temperatures dropped below -3 °C. For October and November, the average relative humidity was 96% and the total precipitation was 106 mm.

Figure 2 illustrates the weather from March to December 2023. 2023 was 0.8 °C warmer than the long-term average. The second quarter was dry and warm. The average air temperature was 0.9 °C above the long-term average. The average relative humidity of the quarter was 63.5% and the total precipitation for the three months was 74 mm. The average temperature of the third quarter was 1.3 °C above the long-term average; the relative humidity was 85.5% and the total precipitation was 272 mm. August was warm, with an average temperature of 18.2 °C and a high total precipitation of 108 mm. September remained warm, with an average monthly temperature 15.3 °C, and there were no night frosts. The average temperature of the month was 3.6 °C above the long-term average. The total precipitation was low at 60 mm. The average temperature for October was 5.5 °C, which was 0.4 C below the long-term average and with very high precipitation (152 mm). The first slight night frost occurred on 9 October, and already on 10 October, the night temperature dropped below -4 °C for the first time. The average relative humidity in October was 90.9% and the total precipitation was 151 mm.

The graphs in Figure 3 display the weather from March to December 2024. The year was 1.8 °C warmer than the long-term average. The second quarter was dry and warm. The average air temperature was 2 °C higher than the long-term average. The average relative humidity for the quarter was 72.2%, and the total precipitation was 149 mm, with only 6 mm falling in May. The average temperature of the third quarter was 1.9 °C above the long-term average; the relative humidity was 85.9% and the total precipitation was 383.8 mm. The average monthly temperature in August was 17.4 °C, and a high amount of precipitation (125.8 mm) was observed. September was warm, with an average temperature 14.5 °C, and high precipitation (81 mm). There were no night frosts observed. The average temperature of the month was 3.8 °C higher than the long-term average. In October, the average temperature was 7.8 °C, which was 1.9 C above the long-term average, but at the end of September, night frosts began with a temperature below -1 °C, and on 16 October, there was already the first frost below -3 °C. The average

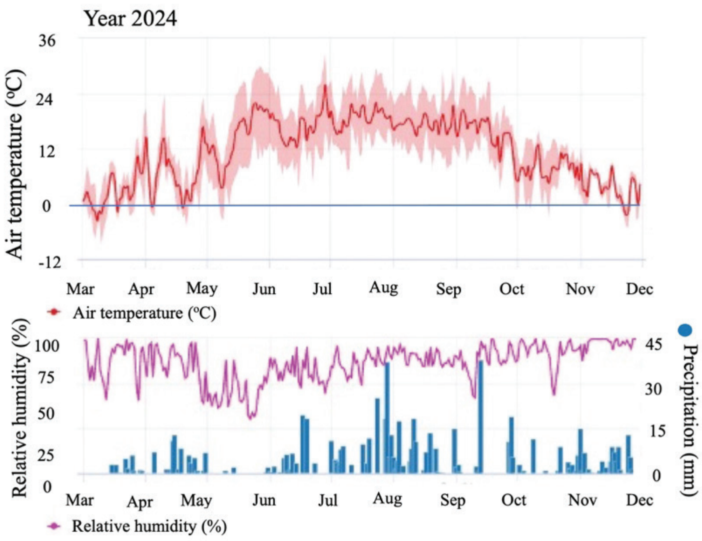

Figure 3. The weather data graph for March–December.

relative humidity in October was 89.9% and the total precipitation was 47 mm.

In 2022, the harvesting frequency and duration varied between cultivars: 'Polka' and 'Delniwa' were harvested 23 times from 21 August to 4 November; 'Jantar' was harvested 19 times from 9 September to 4 November; 'Poemat' was harvested 21 times from 26 August to 4 November; and the 'Endrosadira' cultivar was harvested 16 times from 16 September to 4 November. In 2023, cultivars 'Polka' and 'Delniwa' were harvested 17 times from 13 August to 2 October; 'Jantar', 'Poemat', 'Poemat' were harvested 12 times from 30 August to 2 October. In 2024, cultivars 'Polka' and 'Delniwa' were harvested 14 times from 15 August to 26 September; cultivar 'Poemat' was harvested 13 times from 18 August to 26 September; cultivars 'Jantar' and 'Endrosadira' were harvested 11 times from 25 August to 26 September. During harvesting, marketable quality of fruit and damaged fruit were always harvested and weighed separately. To calculate the total yield, the marketable fruit and the damaged fruit, i.e. fruit damaged by rain and infected with grey mould (*Botrytis cinerea*), were totalled. Fruit weight was determined by weighing of twenty-five fruits. To determine the content of total dissolved solids and total acids in the juice, 100 g of fruit from each cultivar was weighed, placed in a plastic storage box, and stored in a freezer at -23 °C. Analyses were performed after the end of the harvest period. Before the analysis, the samples were thawed at room temperature, crushed and homogenised in a mortar. The total soluble solids (TSS, °Brix) and total acids (TA, % acidity) of the homogenised juice were measured using an ATAGO PAL-BXIACID F5 pocket Brix/acidity meter. A 1:50 dilution with distilled water was used to determine the total acid content. The TSS/TA ratios were calculated from the measured data. Data processing, statistical analysis, and graphing were performed using OriginPro 2020b software (OriginLab Corporation). Statistical effects were assessed using one-way analysis of variance (ANOVA), with different letters indicating significant differences according to Tukey's HSD post hoc test ($p<0.05$).

Results

The beginning and duration of the harvesting periods for the raspberry cultivars 'Polka', 'Jantar', 'Delniwa', 'Poemat' and 'Enrosadira' over the three years (2022–2024) are presented in Figure 4. In the planting year of 2022, the harvest generally began later compared to the subsequent two years: 'Polka' and 'Delniwa' began to yield 6–8 days later; 'Jantar' 11–16 days later; 'Enrosadira' 18–23 days later. In 2022, the start of the harvest for the cultivar 'Poemat' began four days earlier than in 2023, but was nine days later than in 2024. Year 2022 was distinguished by the longest harvest period compared to the following two years. In 2022, the harvest period for the cultivars 'Polka', 'Delniwa' and 'Poemat' lasted 71–76 days and for the cultivars 'Jantar', 'Enrosadira' lasted 50–57 days. The harvest period for all raspberry cultivars ended on 4 November. In 2023, the harvest period for 'Polka' and 'Delniwa' was 51 days, and the harvest period for 'Jantar', 'Poemat' and 'Enrosadira' was 34 days. The harvest period for all cultivars ended on 2 October. In 2024, the harvest period for 'Polka', 'Delniwa' and 'Poemat' was 40–43 days, and the harvest period for 'Jantar' and 'Enrosadira' was 33 days. The harvest period ended on 26 September.

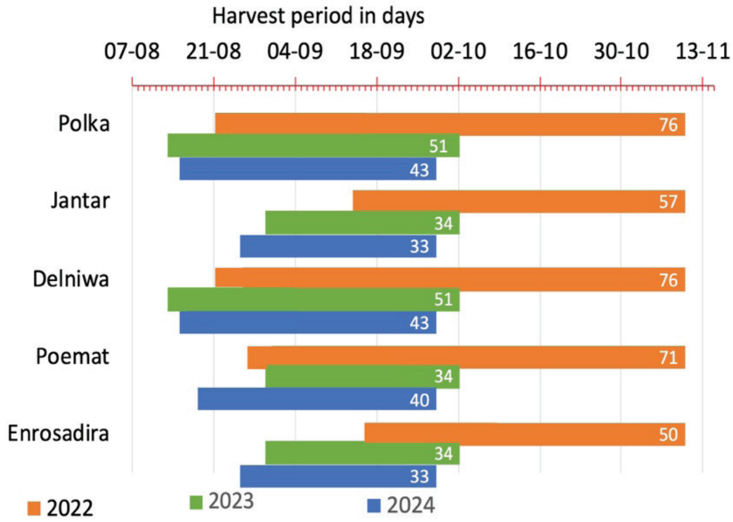

Figure 4. The harvesting periods for the raspberry cultivars in the years 2022–2024.

Table 1

The total yield per bush (g) of the raspberry cultivars and the percentage of spoiled fruit of the average yield in 2022, 2023 and 2024

Cultivar	Total yield per bush (g)			Percentage of spoiled fruits (%)		
	2022	2023	2024	2022	2023	2024
Polka	481.7±78.9 ^{d*}	314.4±98.3 ^{b}	180.7±47.7 ^{c}	30.3±4.4 ^{b}	35.3±10 ^{ab}	30.5±4.2 ^{b}
Jantar	517.4±53.3 ^{cd}	384.0±41.7 ^{b}	460.1±43.6 ^{b}	27.0±6.5 ^{b}	26.3±4.6 ^{b}	28.0±6.3 ^{bc}
Delniwa	726.6±189.2 ^{bc}	424.9±76.2 ^{b}	437.0±70.8 ^{b}	31.8±3.4 ^{ab}	35.0±4.6 ^{ab}	35.0±3.9 ^{b}
Poemat	885.7±44.6 ^{b}	584.1±48.3 ^{a}	835.5±163.3 ^{a}	18.3±1.7 ^{c}	22.8±2.1 ^{b}	17.8±4.2 ^{c}
Enrosadira	1133.3±122.2 ^{a}	410.9±44.9 ^{b}	247.9±138.2 ^{bc}	39.5±1 ^{a}	47.5±5.1 ^{a}	54.8±4.7 ^{a}

**Mean ±standard deviation (n = 4) with different letters indicating significant differences according to Tukey test (p < 0.05).*

The average total yield per bush (g) of the raspberry cultivars observed in the experiment in 2022, 2023, 2024 are shown in Table 1. The average total yield per bush (g) for three years (2022–2024) is graphically illustrated in Figure 5. In the three years studied, 2022 was the year with the highest total yield for all raspberry cultivars.

In 2022, the highest total yield was obtained from the cultivar 'Enrosadira', followed by 'Poemat', which also stood out from the others with a very good quality yield. The difference in the average yield of the cultivar 'Delniwa' between the trial replicates was large, which made its yield not statistically significantly different to both the higher-yielding 'Poemat' and the lower-yielding 'Jantar'. The yield of the cultivar 'Jantar' was not statistically different from that of 'Polka', the cultivar with the lowest yield in 2022. In 2023, 'Poemat' was the only cultivar with a significantly higher yield than the others, which had statistically similar lower yields. In 2024, the cultivar 'Poemat' achieved the highest yield, surpassing 'Jantar' and 'Delniwa' by more than one-third, and yielding three times as much as both 'Polka' and 'Enrosadira'.

In the comparison of the average yield per bush over the three years (2022–2024), the cultivar 'Poemat' clearly showed the most stable and highest results. The cultivar 'Enrosadira' showed the most significant year-on-year yield decrease. 'Jantar' and 'Delniwa' had a consistently good average yield over the three years. The cultivar 'Polka' turned out to be a lower-yielding cultivar, consistently yielding less than the others in all study years.

Table 1 presents the percentage of spoiled fruit from the total yield for each raspberry cultivar observed during the experiment from 2022 to 2024. The three-year (2022–2024) average percentage of spoiled fruit from the total yield is graphically illustrated in Figure 6. In 2022, the cultivar 'Enrosadira' clearly stood out from other cultivars with the highest percentage of fruit spoilage of almost 40%. The percentage of fruit spoilage for the cultivars 'Polka', 'Jantar' and

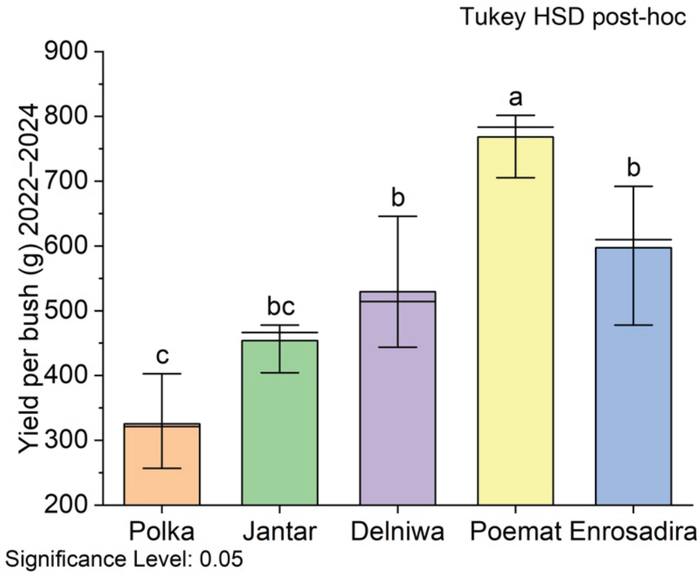

Figure 5. The raspberry cultivars, the three-year (2022–2024) average total yield per bush (g).

'Delniwa' was at the level of 30%. In 2022, the cultivar 'Poemat' stood out with the lowest percentage of fruit spoilage of less than 20%. In 2023, the fruit spoilage rate for the cultivar 'Enrosadira' was 47.7%, which was the highest among the evaluated cultivars. The percentage of fruit spoilage for the cultivars 'Polka' and 'Delniwa' increased to 35%. A small increase in the fruit spoilage rate for the cultivar 'Poemat' and a small decrease in the fruit spoilage rate for the cultivar 'Jantar' brought them to the group of cultivars with the lowest fruit spoilage percentage in 2023. In 2024, the fruit spoilage rate for the cultivar 'Enrosadira' had already risen to nearly 55%, which remained the highest among the assessed cultivars. The percentage of fruit spoilage for the cultivars 'Polka' and 'Delniwa' stayed at 30–35%. Despite a small increase compared to the previous two years, the fruit spoilage rate for the cultivar 'Jantar' again remained slightly lower than 30%. The spoilage rate for the cultivar 'Poemat' fell to an all-time low of less than 18% in 2024. Among the raspberry cultivars studied, the three-year average percentage of spoiled fruit was the lowest for the cultivar 'Poemat', remaining below 20%. The 'Jantar' cultivar also stood out for its low fruit spoilage rate, which remained below 30% on average over three years. 'Polka' and 'Delniwa' formed a group with a

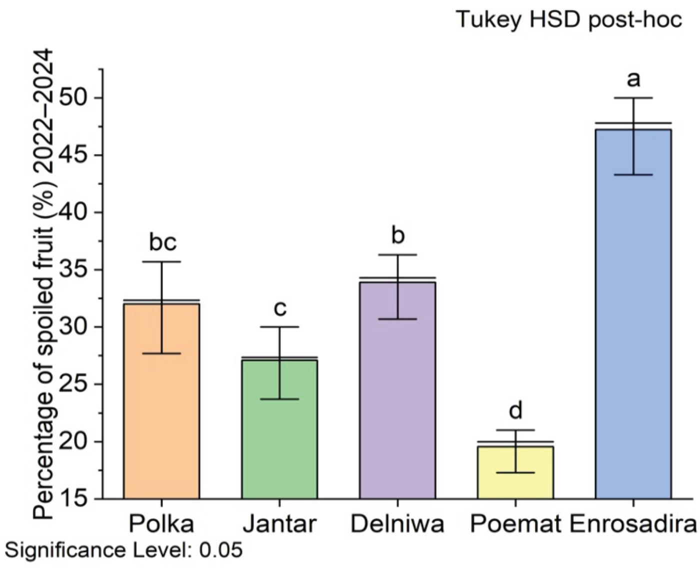

Figure 6. The percentage of spoiled fruit in the yield of raspberry cultivars (average of 2022–2024).

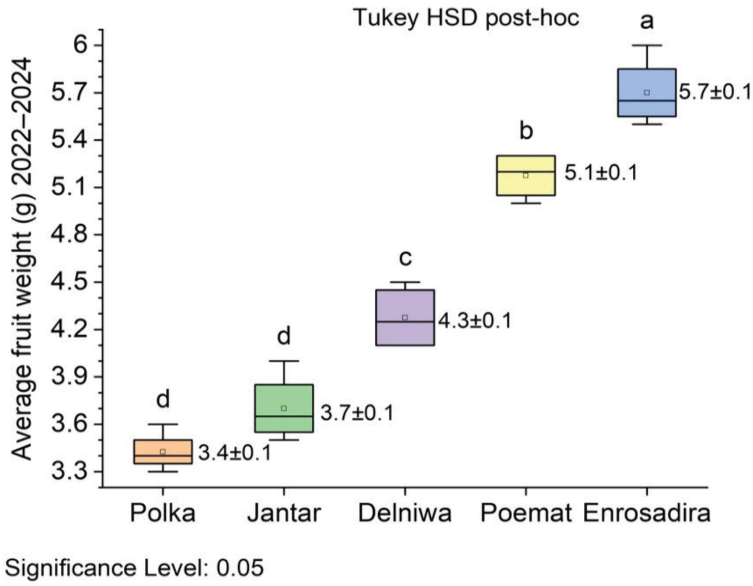

Figure 7. The average fruit weight of raspberry cultivars over three years (2022–2024).

Table 2

The content of TSS and TA in the fruit juice of raspberry cultivars in 2022, 2023, and 2024

Cultivar	TSS (°Brix)			TA (%)		
	2022	2023	2024	2022	2023	2024
Polka	13.57±0.06 a*	8.90±0.05 c	10.23±0.06 b	1.13±0.02 c	1.31±0.01 c	0.89±0.01 d
Jantar	10.13±0.06 d	9.72±0.03 a	10.40±0.01 b	1.77±0.01 a	1.64±0.01 a	1.30±0.01 a
Delniwa	12.33±0.06 b	9.47±0.03 b	11.30±0.01 a	1.25±0.01 b	1.16±0.01 e	1.06±0.01 b
Poemat	11.43±0.12 c	8.03±0.06 d	9.53±0.06 c	1.24±0.01 b	1.26±0.01 d	0.95±0.01 c
Enrosadira	9.43±0.12 e	7.85±0.05 e	9.47±0.06 c	1.26±0.01 b	1.46±0.01 b	1.07±0.01 b

**Mean ±standard deviation (n = 4) with different letters indicating significant differences according to Tukey test (p < 0.05).*

three-year average fruit spoilage rate of just over 30%. Over the three years, the proportion of spoiled fruit for 'Enrosadira' increased with each year, reaching a three-year average of 47.2%.

The three-year (2022–2024) average fruit weight of raspberry cultivars is graphically illustrated in Figure 7. Over the three years, the highest average fruit weight was measured for the cultivar 'Enrosadira', with a three-year average of 5.7 g. The second highest three-year average fruit weight was for 'Poemat' (5.1 g) and third highest for 'Delniwa' (4.3 g). The lowest average fruit weights were recorded for 'Jantar' (3.7 g) and 'Polka' (3.4 g). The difference between the average weights of these two cultivars was not statistically significant.

The content of the total soluble solids (TSS) and total acids (TA) in the fruit juice of raspberry cultivars in 2022, 2023 and 2024 is shown in Table 2.

In 2022, the content of TSS significantly varied among all cultivars. 'Polka' recorded the highest concentration at 13.57 °Brix, while 'Enrosadira' had the lowest at 9.43 °Brix.

In 2023, the TSS content of all raspberry cultivars was significantly lower than in 2022, and differed significantly among the cultivars. The highest TSS content was detected for the cultivar 'Jantar' (9.72 °Brix), and the lowest for the cultivar 'Enrosadira' (7.85 °Brix).

In 2024, the TSS content of all raspberry cultivars was slightly higher than in 2023, but not all values differed significantly from one another. The highest content of TSS was measured for the cultivar 'Delniwa' (11.30 °Brix), and the lowest for the cultivar 'Enrosadira' (9.47 °Brix).

In all three years, the cultivar 'Jantar' had the highest TA content among the evaluated raspberry cultivars. In 2022 and 2024, the cultivar 'Polka' had the lowest TA content, while in 2023, it was the 'Delniwa' cultivar.

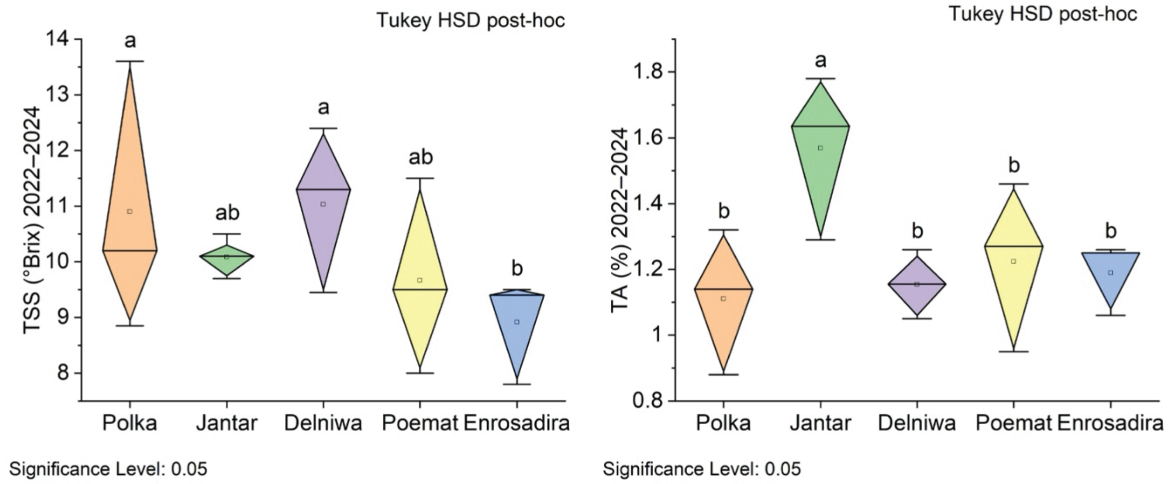

Figure 8. The three-year (2022–2024) mean content of TSS and TA in the fruit juice of raspberry cultivars.

The three-year (2022–2024) average TSS and TA content in the fruit juice of the raspberry cultivars is presented in Figure 8. 'Polka' and 'Delniwa' had the highest mean TSS content (10.9 and 11.0 °Brix, respectively). The cultivars 'Jantar' and 'Poemat' were in the middle group with the average TSS content of 10.1 and 9.7 °Brix, respectively. The cultivar 'Enrosadira' had the lowest TSS content (8.9 °Brix). The highest three-year mean TA value was for the cultivar 'Jantar' (1.57%). Other raspberry cultivars had significantly lower TA values ranging from 1.11 to 1.21%.

The three-year (2022–2024) mean TSS ratio to TA, which characterises the taste properties, differed significantly among the cultivars. It was the highest for the cultivar 'Polka' and the lowest for 'Jantar' (Figure 9).

'Polka' stood out from the other cultivars with the highest TSS/TA ratio in the three-year average. 'Delniwa' also had a high TSS/TA ratio, but not statistically significantly different from 'Polka'. The cultivar 'Poemat' remained in the middle position with its moderate to low TSS/TA ratio, which was not statistically significantly different from the other cultivars except for 'Polka'. The cultivar 'Jantar' had the lowest TSS/TA ratio or the worst taste balance among these cultivars. The 'Enrosadira' TSS/TA ratio was lower than that of 'Poemat' and higher than that of 'Jantar', but did not differ statistically from either.

Discussion

An evaluation of five primocane-fruiting red raspberry cultivars ('Delniwa', 'Enrosadira', 'Jantar',

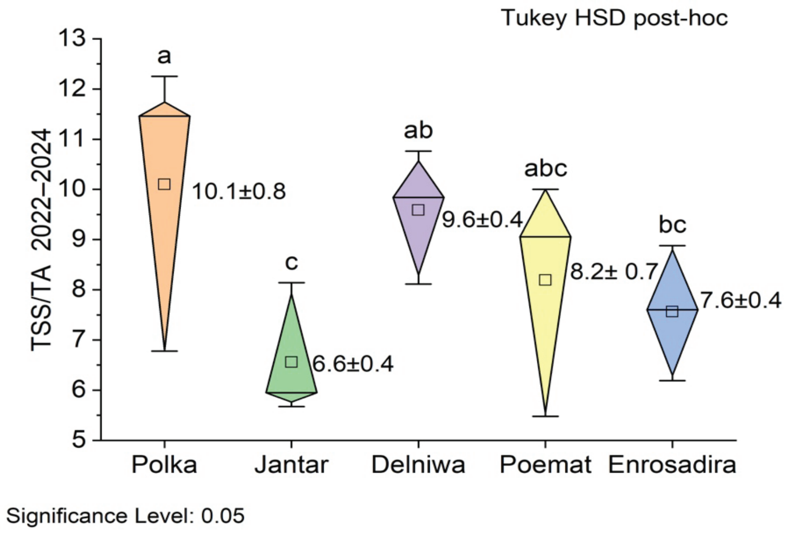

Figure 9. The three-year (2022–2024) mean TSS ratio to TA of raspberry cultivars.

'Poemat' and 'Polka') over the three-year period from 2022 to 2024 under Estonian climatic conditions revealed meaningful differences in yield, fruit quality and abiotic stress tolerance between the cultivars. The Polish cultivar 'Poemat' showed remarkable adaptability, providing the highest and most stable yield in all three years with the lowest fruit spoilage rate. This three-year consistency was maintained despite the harvest periods of varying lengths and accompanying fluctuations in temperature and humidity levels. This shows that this cultivar is tolerant of temperature and humidity fluctuations, making it suitable for Estonia's variable climate. At the same time, the 'Poemat' cultivar's fruit taste indicator, with a TSS/TA ratio of 8.2, was at a medium level, and its average fruit weight of 5.5 g was the second highest. By contrast, the Italian cultivar 'Enrosadira' had the largest average fruit weight (5.7 g), but exhibited drastic yield volatility (1,133 g/bush in 2022 versus 248 g/bush in 2024) and the highest spoilage rate (47.2% on average). This is likely due to its susceptibility to *Botrytis cinerea* under high humidity conditions (>85% during the 2023–2024 harvest period). This vulnerability highlights the poor suitability of the cultivar to Baltic Sea conditions, where pre-harvest rainfall and humidity are recurrent year-to-year stressors (Jarvis, 1962; Kozhar & Peever, 2018). Fruit quality characteristics also differentiated the cultivars. 'Polka' – despite its low yield and low fruit weight– stood out for its taste (highest mean TSS and TA ratio), which is due to its high total soluble solids content in the juice. However, in the 'Polka' cultivar, the rapid decline in yield after first growing year indicates climate incompatibility. The cultivar 'Delniwa' was in balance, with a moderate yield and high TSS content, along with good fruit taste characteristics (high mean TSS and TA ratio). The average yield of the cultivar 'Jantar' was stable over the years, but on the lower side. 'Jantar' showed resistance to spoilage but the fruit taste indicator (TSS and TA ratio) was pulled down by the high TA content. These findings support genotype-dependent nutrient variability (Fotirić Akšić *et al*., 2022; Mazur *et al*., 2014), where, in the fruit juice, the TSS and titratable acids content fluctuates between years, reflecting weather effects – e.g., the cooler year with lower precipitation in 2022 increased the TSS content, while the warmer period with a lot of precipitation in seasons 2023–2024 lowered the TSS correlation with a shift in TA. Weather anomalies seriously influenced the results. Weather anomalies had a significant impact on the results. The warm weather with moderate precipitation during the second quarter in July and August, likely accelerated fruit development. However, the warm September and October, combined with high precipitation and humidity (85–90%), exacerbated spoilage, particularly for 'Enrosadira' and 'Delniwa'. This is consistent with previous studies that have linked moisture-induced outbreaks of *Botrytis cinerea* to fruit loss (Privé *et al*., 1993; Vanwalleghem *et al*., 2023). Heavy rainfall also contributed to the irregular pollination of raspberry flowers and uneven fruit development, reducing quality and contributing to spoilage. Notably, the stability of 'Poemat' under varying stress factors was maintained over the three experimental years. Since all conditions were the same for all raspberry cultivars during the testing period, this emphasises the cultivar's genetic resilience, making 'Poemat' a reliable choice for production plantations and breeding in the Baltic region.

Conclusions

This three-year study identifies 'Poemat' as the optimal raspberry cultivar for Estonian cultivation due to its high and stable yield (768.4 g/bush), low susceptibility to spoilage (≤18%), and adaptability to climatic stressors. While the cultivar 'Delniwa' offers good fruit quality (TSS 11.0 °Brix; TSS and TA ratio: 10.1) and 'Jantar' shows relatively high spoilage resistance (27.1%), their stable moderate yield reduces their practicality. 'Enrosadira' and 'Polka' are not suitable for Estonia: 'Enrosadira' due to its extreme yield volatility and spoilage issues, and 'Polka' due to its consistently low yield. The study concludes that the cultivar 'Poemat' should be preferred for commercial planting to ensure a yield that is resilient to climate change. The stability characteristics of the cultivar 'Poemat' and the fruit quality could be considered as potential for selecting as the parent cultivar for breeding cultivars that are well adapted to the Baltic climate. During periods of high humidity, it is advisable to protect the raspberry plantation from rain and to use Botrytis cinerea control methods suitable for the plantation, especially for susceptible varieties such as 'Enrosadira'.

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