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ORIGINAL PAPER

Analysis of the stability of nutritional and antinutritional components in organically grown potato tubers*

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Abstract

In the years 2021-2023, field experiments were conducted to assess and select the most stable potato varieties for cultivation in an organic production system in terms of a specific component content. The experiments were conducted in six locations (Jadwisin, Krzyżewo, Lućmierz, Osiny, Tarnów, Węgrzce) on ten edible potato varieties (very early: Pogoria, Surmia, Tonacja, early: Arizona, Lilly, and medium early: Connect, Irmina, Mariola, Red Lady, Soraya). The content of basic components, starch, vitamin C, nitrates (V), glycoalkaloids and dry matter, was determined in the tubers after harvest. The results were analyzed using the AMMI model for variance analysis. The significance of the studied factors and their contribution to variability were assessed. Then, the stability of the analyzed features of the tubers of the studied varieties was determined based on three measures: feature superiority measure – Pi, the Eskridge's feature reliability measure – Ri, the Kang's stability measure – YSi. It was determined that the environmental factor has the greatest impact on the content of vitamin C, nitrates(V) and glycoalkaloids, and the variety factor has the greatest impact on the level of starch and dry matter in tubers. The highest degree of broad adaptation of the analyzed measures in relation to the content of dry matter and starch was obtained by the Mariola variety, vitamin C by the Lilly variety, nitrates(V) by the Tonacja variety and glycoalkaloids by the Red Lady variety.

Keywords: component, location, potato, variety, year

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INTRODUCION

Potato varieties recommended for organic farming should be characterized by the highest possible resistance to potato blight and produce high yields (Zarzyńska et al. 2023). Because of their various uses, potato tubers should meet the requirements set for the main components, that is the content of starch, vitamin C, nitrates and glycoalkaloids (Kołodziejczyk 2013, Kazimierczak et al. 2019). It should also be emphasized that among the consumed varieties of vegetables, potatoes still constitute the largest share in diet in Poland, mainly because of their high nutritional value (Dzwonkowski 2022). Tubers of edible varieties should be characterized by a starch content of 10 to 16%, a high content of vitamin C, and the lowest possible amounts of nitrates and glycoalkaloids (Leszczyński 2012). When choosing a variety, it is important that its tubers not only have specific composition, but also maintain stable content levels under changing environmental conditions (Flis et al. 2014). Studies on potato varieties must therefore take into account the weather conditions, especially extreme weather events like drought, excessive rainfall or high temperature, and the type of soil (Woźniak, Kawecka-Radomska 2016, Jończyk, Martyniuk 2017, Rymuza et al. 2017, Flis, Tatarowska 2019, Kwiatkowski, Harasim 2020,). Determination of the genotype-environmental variability should be a recommended step in choosing varieties from a wide pool of available varieties to meet specific needs. A significant role in any assessment is played by the selection of an appropriate statistical method (Yan et al. 2007, Gauch et al. 2008, Mądry, Iwańska 2011*a*,*b*). A measure of adaptation can be used In studies on the interaction of varieties with the environment (Padarewski and Mądry 2012). The broad adaptation measure expresses the ability of a variety to obtain high productivity and a specific content of components in variable environmental conditions, and the location of experiments or years of research may be included in such studies. An assessment of the broad adaptation of varieties is composed of the superiority of the feature – Pi (Lin, Binns 1988), the reliability of the advantage of the feature – Ri (Eskridge, Mumm 1992) and the Kang's measure of stability – YSi (Kang 1993). The aim of the study was to select potato varieties as stable as possible in terms of the content of specific components for cultivation in an ecological system based on the broad adaptation measure. The study verified the research hypothesis that selected environmental factors have a significant influence on the level of basic components of potato tubers from selected varieties.

MATERIAL AND METODS

The experiment was carried out in 2021-2023, on ten edible potato varieties of different earliness grown in six locations on certified organic experimental fields (Tables 1, 2).

Table 1

Location of experiments

Location	Geographical location	
	latitude	longitude
Jadwisin	52°45′N	21°63′E
Krzyżewo	53°01′N	22°46′E
Lućmierz	52°12′N	19°08′E
Osiny	51°28′N	22°04′E
Tarnów	50°35′N	16° 47′E
Węgrzce	50°07′N	19°59′E

Fig. 1. Location of the experimental fields in Poland

Table 2

Characteristics of potato varieties grown in the experiment. Years 2021-2023

Variety	Bredeer and country	Maturity group	Skin/flesh color	Resistance to *Phytophthora infestans*#
Pogoria	PMHZ Strzekęcino – Poland	very early	yellow/yellow	3
Surmia	HZ Zamarte – Poland	very early	yellow/light yellow	3
Tonacja	PMHZ Strzekęcino – Poland	very early	yellow/light yellow	3
Arizona	Agrico – Netherlands	early	yellow/light yellow	4
Lilly	Solana – Germany	early	yellow/yellow	4
Connect	Solana – Germany	medium early	yellow/yellow	5
Irmina	HZ Zamarte – Poland	medium early	yellow/light yellow	3-4
Mariola	Europlant – Germany	medium early	yellow/yellow	5
Red Lady	Solana – Germany	medium early	red/yellow	5
Soraya	Norika – Germany	medium early	yellow/yellow	5

9 – full resistance, 1 – no resistance

Two-factor experiments (factor I – environment, factor II – variety) were conducted in a randomized block design, with 3 replications. The experimental fields were set up on light and medium soil (Table 3).

Table 3

Characteristics of soil conditions, reaction and nutrient content

Localities	Category	Textural classes#	Reaction pH in KCl	P (mg kg)	K (mg kg)	Mg (mg kg)
Jadwisin	light	loamy sand	6.4	95	90	55
Krzyżewo	light	loamy sand	5.4	81	55	25
Lućmierz	light	loamy sand	5.5	75	46	75
Osiny	medium	sandy loam	6.0	50	75	74
Tarnów	medium	sandy loam	6.6	95	180	80
Węgrzce	medium	loam	6.5	80	215	82

IUSS Working Group WRB 2015

The study years had variable weather during the growing season (April – September) – Table 4. In 2021, regardless of the location, the total rainfall

Table 4

The pattern of weather conditions during the growing season (April – September) in the years of research

Years	Localization						IV-IX
	J+	K+	L+	O+	T+	W+	
Sum of rainfalls (mm)							
2021	486.6	433.5	487.0	550.3	400.3	668.6	504.4
2022	318.3	406.1	435.2	328.9	452.0	403.7	390.7
2023	255.6	239.0	336.2	330.8	401.7	487.0	341.7
Multi-year	**352.0**	**382.9**	**385.6**	**356.0**	**412.8**	**445.0**	
Mean air temperature (°C)							
2021	15.4	15.7	15.2	15.0	14.7	15.6	15.3
2022	15.5	14.4	15.8	15.0	13.7	16.4	15.1
2023	16.7	15.9	16.9	16.1	15.6	16.7	16.3
Multi-year	**14.6**	**15.2**	**15.8**	**14.8**	**15.8**	**15.1**	
Selyaninov's hydrothermal coefficients (K)++							
2021	1.7	1.7	1.7	1.9	1.0	1.8	1.6
2022	1.2	1.5	1.2	1.0	1.7	0.8	1.2
2023	0.9	0.6	0.9	1.0	0.9	0.9	0.9

+ J – Jadwisin, K – Krzyżewo, L – Lućmierz, O – Osiny, T – Tarnów, W – Węgrzce

++ The value of the Selyaninov's coefficient (Skowera 2014): extremely dry $k \leq 0.4$, very dry $0.4 < k \leq 0.7$, dry $0.7 < k \leq 1.0$, rather dry $1.0 < k \leq 1.3$, optimal $1.3 < k \leq 1.6$, rather humid $1.6 < k \leq 2.0$, humid $2.0 < k \leq 2.5$, very humid $2.5 < k \leq 3.0$, extremely humid $k > 3.0$

for the period April–September was 504.4 mm. In all locations, except for Tarnów, the rainfall was above the multi-year total. The highest rainfall was recorded in Węgrzce, and the lowest – in Tarnów. The lowest average air temperature was also recorded in Tarnów, while the highest was in Krzyżewo. The hydrothermal coefficient ranged from 1.0 (dry) in Tarnów to 1.8 (quite humid) in Węgrzce. Overall, K=1.6 indicated that 2021 was the optimal year. In 2022, the rainfall level was 113.7 mm lower than in 2021. The year 2022 was also colder than the other two years. The highest rainfall and the lowest average air temperature were recorded in Tarnów. The lowest rainfall occurred in Jadwisin, and the highest air temperature was noted in Węgrzce. The hydrothermal coefficient ranged from 0.8 (dry) in Węgrzce to 1.7 (quite humid) in Tarnów. Overall, year 2022 was quite dry (K=1.2). The following year, 2023, was generally characterized by the lowest rainfall, which reached 341.7 mm, and it was the warmest year of the three. The average air temperature in 2023 for the entire plant growing period was 16.3°C. The highest rainfall in 2023 was recorded in Węgrzce, and the lowest was in Krzyżewo. The average air temperature in 2023 was the highest in Lućmierz, while the lowest one was recorded in Tarnów. The hydrothermal coefficient ranged from 0.6 (very dry) in Krzyżewo to 1.0 (dry) in Osiny. Overall, year 2023 was dry (K=0.9).

The experiments were conducted using the agricultural technology recommended for organic farmig, maintaining a similar level of agrotechnical procedures in all locations. A 4-field crop rotation was generally used, and a 5-field one was implemented only in Jadwisin. In all locations, the preceding crop was cereal plants. In Osiny, clover was cultivated with grasses in the rotation system. Weeds were controlled mechanically by performing 4-6 treatments with a weeder, ridger or hoe. Potato plant protection against potato blight (2 or 3 treatments) was performed using Miedzian 50 WP (copper oxychloride) at a dose of 2 kg ha^{-1}. The Colorado potato beetle (1 or 2 treatments) was eradicated using Spintor 240 SC (spinosad) at a dose of 0.15 dm^3 ha^{-1}. Potatoes were planted between the 10th and 30th of April, at a spacing of 75 x 33 cm. Harvesting was carried out in between the 20th and 31st of August (very early and early varieties) and between the 10th and 30th of September (medium early varieties). The plot size was 14.85 m^2, and the number of plants per plot was 60. Harvesting was carried out after the plants had reached full maturity, at the development stage of 97-99 on the BBCH scale (Klingauf 2001). During harvesting, 5-kilogram samples of tubers with a diameter of 35 to 60 mm were taken from each plot to determine the content of basic components. The dry matter content was determined by a two-stage drying method, at temperatures of 60 and 105°C. The starch content was determined by the Evers polarimetric method (PN-EN ISO 10520 2002). Starch hydrolysis was carried out in a boiling water bath, and then the protein was precipitated using phosphoric-tungstic acid. The starch content was read on an automatic Polamat S polarimeter. Vitamin C content was determined as the sum of L-ascorbic acid and dehydroascorbic acid using the Tillmans's method by titration with a solution of 2,6-dichlorophenolindophenol (Rutkowska 1981). The NO_3 (V) nitrate content was determined reflectometrically using Merckoquant nitrate ion test strips and the RQ Flex Merck measuring device. In the presence of an acidic buffer, nitrate ions react with an aromatic amine to form diazonium salt, which, in reaction with N-(1-naphthyl)ethylenediamine, forms a red-violet dye. The concentration of this dye is determined reflectometrically (Merck 2023). The total glycoalkaloid content (cTGA) was determined colorimetrically. TGA was extracted with hot ethanol, precipitated with concentrated ammonia and a color reaction was performed using Clark's reagent, concentrated phosphoric acid with the addition of formaldehyde (Bergers 1980).

The research results were statistically processed using the Statistica 13.3 program with the analysis of variance (TIBCO Software Inc. 2017) and using the Naturalist's Set for calculations. The analysis of mean comparisons was performed using the Tukey's test at the level of p=0.05. The measures of broad adaptation: the measure of feature superiority – (Pi), Eskridge's feature reliability measure – (Ri), Kang's stability measure – (YSi) were determined based on the results obtained from the analysis according to the AMMI model (StatSoft Polska Sp. z o. o., 2018).

RESULTS AND DISCUSSION

Analysis of the contribution of factors to variability

The study found significant differences in the content of components in tubers depending on environmental and variety-related factors and their interaction. It was shown that the cultivation environment had a greater impact on the content of nitrates (78.3%), vitamin C (59.5%) and glycoalkaloids (44.1%) in tubers. The variety as a factor had a stronger influence on the content of dry matter (42.7%) and starch (38.5%) in tubers. The interaction of these factors had the biggest effect on the content of vitamin C (37.6%) in tubers (Table 5). In previous study, a similar effect of the environment on the content of glycoalkaloids (43.7%) and a weaker effect on the content of vitamin C (43.1%), nitrates (18.5%) and starch (6.8%) was obtained (Trawczyński 2016). The greatest contribution of the variety factor to the formation of starch content in tubers was also confirmed (Trawczyński 2016). In the study by Barbaś and Sawicka (2015), the share of vitamin C in the total variability was 44%, and the environmental factor had a dominant influence on its content. In earlier studies, Sawicka et al. (2014) proved that vitamin C was responsible for 55% of variability, and depended mainly on the genotype. A greater influence of the genotype was also noted in shaping the level of glycoalkaloids in tubers (Trawczyński, Wierzbicka 2011).

Table 5

Significance of the studied factors and share in variability (%)

Characteristics	Effects	1	2	1x2	3	4
Dry matter (%)	variability %	27.9	42.7	27.9	0.2	1.3
	F-statistica	294	1169	45	1.0	-
	p-value	0.0001	0.0001	0.0001	0.08	-
Starch (%)	variability %	30.4	38.5	30.2	0.1	0.8
	F-statistica	450	1698	78	2.0	-
	p-value	0.0001	0.0001	0.0001	0.02	-
Vitamin C(mg kg^{-1})	variability %	59.5	1.9	37.6	0.3	0.7
	F-statistica	466	95	110.3	3.4	-
	p-value	0.0001	0.0001	0.0001	0.0001	-
Nitrates (mg kg^{-1})	variability %	73.8	9.3	15.8	0.4	0.7
	F-statistica	429.4	478.3	47.68	4.67	-
	p-value	0.0001	0.0001	0.0001	0.0001	-
Glycoalkaloids (mg kg^{-1})	variability %	44.1	29.6	25.4	0.2	0.7
	F-statistica	600.9	1455	73.5	1.9	-
	p-value	0.0001	0.0001	0.0001	0.001	-

1 – environment, 2 – variety, 3 – replication, 4 – error

The influence of the environmental factor on the content of components in tubers

The environmental factor included the weather conditions in the locations and soil properties. The highest dry matter content in tubers was found in Krzyżewo, where precipitation was below the multi-year total and the growing season was moderately warm (Table 6). Previous studies have shown that dry and warm weather contribute to an increase in the dry matter content in tubers compared to cool and humid years (Kołodziejczyk 2014). The lowest dry matter content in tubers was obtained in Jadwisin, where the weather was quite dry and very warm, especially in the third year of the study. The difference in the dry matter content in tubers between these locations, in absolute values, was over 6%. Coincident results were obtained as regards the starch content in tubers. Due to its greatest share in potato tubers (75-80% in dry matter), starch largely detetrmines the level of dry matter (Mystkowska 2019). The highest levels of starch in tubers were found in Krzyżewo, and the lowest ones – in Jadwisin. If the air temperature is too high, it may adversely affect the starch content in tubers and reduce the dry matter level, which has been confirmed previously (Trawczyński 2022). The environmental factor also had significant influence on the varied vitamin C content in tubers. The highest level of vitamin C in tubers was obtained in Tarnów, where the rainfall was closest to the multi-year average.

Table 6

The composition of potato tubers in relation to location of experiments, years 2021-2023

Feature	Location					
	Jadwisin	Krzyżewo	Lućmierz	Osiny	Tarnów	Węgrzce
Dry matter (%)	19.44*e**	20.71*a*	19.67*d*	19.63*d*	20.24*b*	19.87*c*
Starch (%)	13.20*d*	14.02*a*	13.47*c*	13.45*c*	13.98*a*	13.66*b*
Vitamin C (mg kg^{-1})	155.09*f*	164.36*e*	169.28*d*	174.98*c*	178.91*a*	176.63*b*
Nitrates (V) (mg kg^{-1})	39.31*d*	39.94*d*	46.32*b*	116.74*a*	42.72*c*	34.12*e*
Glycoalkaloids (mg kg^{-1})	69.95*f*	124.72*a*	96.85*c*	87.80*e*	106.55*b*	94.45*d*

* Mean values followed by the same letters are not statistically significantly different at p=0.05 level, according to the Tukey's test

In Jadwisin, where a significant rainfall deficiency and higher air temperature than the multi-year average were recorded in two consecutive years, a significantly lowest vitamin C content in tubers was found – over 13% less than in tubers grown in Tarnów. Previous studies have confirmed higher vitamin C content in tubers in years with optimal weather conditions (Barbaś, Sawicka 2015, Pszczółkowski et al. 2019).

Unfavourable weather conditions contributed to an increase in the amount of antinutritional components in tubers. The highest levels of nitrates(V) in tubers was found in Osiny. A rainfall deficit was recorded in this location in two consecutive years, and clover with grasses was grown in the crop rotation. The lowest levels of nitrates(V) in tubers were obtained in Węgrzce, with the highest rainfall among the locations in two years of the study. This trend might be the result of the lability of mineral forms of nitrogen in soil under the influence of changes in its moisture, which has been confirmed by several researchers (Davenport et al. 2005, Shrestha et al. 2010, Clément et al. 2021). Unfavourable weather conditions also resulted in an increase in glycoalkaloids, the second basic antinutritional component in potato tubers. A significantly highest content of glycoalkaloids in tubers was found in Krzyżewo, where the highest rainfall deficit was recorded in one of the years of the study. The difference between the locations with the highest and lowest levels of glycoalkaloids in tubers was 44%. Other studies have confirmed that stress during the plant growing season caused by rainfall deficit or excess and intense sunlight raised the content of glycoalkaloids in tubers (Zarzecka, Gugała 2007, Zarzecka et al. 2013, Hamouz et al. 2014). The study by Frydecka-Mazurczyk and Zgórska (2002) showed that the difference in the level of glycoalkaloids in tubers between the years with extreme weather conditions was over 30%.

Soil properties had lesser impact than weather conditions on the variation of individual components in tubers. Only significantly higher levels vitamin C were obtained in tubers from medium soil: Osina, Tarnów and Węgrzce, than from light soil: Jadwisin, Krzyżewo and Lućmierz (Table 6).

In the study by Pycia et al. (2022), significant difference of over 3% was demonstrated in the starch content in tubers between the two types of soil.

Influence of the variety factor on the content of components in tubers

Variety-specific properties differentiated the content of dry matter and starch more than the content of other components in tubers. The medium early varieties were characterized by a higher content of dry matter and starch in tubers (by 0.8% higher on average) than the very early and early varieties. Studies conducted so far on the earliness of varieties have confirmed this relationship (Bombik et al. 2007, Kołodziejczyk 2013). The highest content of dry matter and starch in tubers was obtained in the variety Connect, while the lowest was found in the variety Arizona (Table 7). In relation to the content of vitamin C in tubers, no significant differences were shown between medium and early varieties. Proven differences in the content of vitamin C in tubers were noted between very early and early varieties. The variety Lilly was characterized by the highest level of this component, while the significantly lowest level of vitamin C in tubers was noted in the varieties Surmia and Pogoria. In previous studies, very early varieties were characterized by a significantly higher level of vitamin C in tubers than medium early varieties (Trawczyński 2021). In relation to the content of nitrates(V) and glycoalkaloids in tubers, significant differences were shown between the varieties, regardless of their earliness. The variety Pogoria had the lowest content of nitrates(V) in tubers (34.31 mg kg^{-1}), and

Table 7

The content of components in tubers in relation to variety. Years 2021-2023

Variety	Feature				
	dry matter (%)	starch (%)	vitamine C (mg kg^{-1})	nitrates(V) (mg kg^{-1})	glycoalkaloids (mg kg^{-1})
Pogoria	20.40*c**	13.75*d*	165.52*d*	34.31*j*	72.63*g*
Surmia	19.68*d*	13.40*e*	165.35*d*	57.12*d*	118.39*d*
Tonacja	18.99*e*	13.10*f*	169.49*c*	74.79*a*	126.85*b*
Arizona	18.62*g*	12.86*h*	172.77*b*	54.14*e*	96.57*e*
Lilly	19.80*d*	12.99*g*	175.11*a*	50.96*g*	81.14*f*
Connect	21.82*a*	15.28*a*	169.57*c*	44.79*h*	123.26*c*
Irmina	20.30*c*	14.08*c*	170.22*c*	53.22*ef*	78.73*f*
Mariola	21.11*b*	14.64*b*	169.82*c*	38.40*i*	65.75*h*
Red Lady	19.76*d*	13.69*d*	170.40*c*	64.12*b*	130.68*a*
Soraya	18.77*f*	12.93*h*	170.49*c*	60.03*c*	73.22*g*

* Mean values followed by the same letters are not statistically significantly different at p=0.05 level, according to the Tukey's test.

the variety Tonacja had the highest level of these compounds (74.79 mg kg^{-1}). In conventional cultivation, a higher level of nitrates(V) is generally found in tubers of early varieties than later ones (Trawczyński, Wierzbicka 2012). It should be assumed that because mineral nitrogen must not be used i n organic cultivation, this relationship has not been confirmed in our study. The varieties to a great extent responded to the accumulation of glycoalkaloids in tubers, regardless of their earliness. Differences in the glycoalkaloid content between cultivars, ranging from 65.75 mg kg^{-1} in tubers of the variety Mariola to 130.68 mg kg^{-1} in the variety Red Lady, were much greater than those concerning the amounts of nitrates(V). Significant variation in glycoalkaloids in tubers between tested potato varieties has been confirmed in other studies (Wroniak, Mazurczyk 2006, Zgórska et al. 2006, Hamouz et al. 2014). It should be added that the highest yield in the previously published report was obtained from the varieties Arizona and Connect (Trawczyński 2024 – in print).

Analysis of component stability in tubers of the studied varieties

The analysis of broad adaptation based on three measures allowed for determining the variability of the amounts of components in tubers, and assessing the stability of varieties in relation to the environmental factor. The measure of feature superiority (Pi) having the value closest to 0 indicated the highest degree of broad adaptation. The measure expressing the formation of the feature for the variety above the environmental average (Ri) reaching a value close to 1 characterized the feature with the highest degree of broad adaptation. The Kang's measure (YSi) constituting the genotypic average of the feature expressed by the highest numerical value for the variety proved its high stability (Mądry, Iwańska 2011). The usefulness of broad adaptation analysis based on the AMMI model for assessing the stability of yield and features of potato varieties has been demonstrated in other studies (Affleck et al. 2008, Gedif et al. 2014, Cadersa et al. 2022). The assessment of the stability of a variety in different environmental conditions, not only in relation to the yield but also the quality of the tubers, should be one of the main determinants of its utility value. In relation to the content of dry matter and starch in tubers, the variety Mariola was characterized by the best measure of superiority (Pi), shaping these components above the environmental average (Ri) and the assessment of stability using the Kang's measure (YSi). As for the variety Connect, a good assessment of the stability of dry matter and starch was shown in relation to the measures (Pi) and (Ri). The best stability determined by all the three measures in relation to the vitamin C content in tubers was determined for the variety Lilly, the content of nitrates(V) – for Tonacja, and the level of glycoalkaloids – for Red Lady (Table 8). The previously published experiment on yields showed that Arizona and Connect varieties were characterized by the best degree of superiority (Pi) of the environmental mean (Ri), and Arizona, Lilly and Soraya varieties also achieved the best Kang's stability measure (Trawczyński

Table 8

Assessment of stability and adaptation indicators for quality features of tubers of tested varieties

Variety	Measure	Dry matter (%)	Starch (%)	Vitamine C (mg kg^{-1})	Nitrates(V) (mg kg^{-1})	Glykoalkaloids (mg kg^{-1})
Pogoria	Pi	2	2	427	1732	3330
	Ri	0.67	0.72	0.44	0.06	0.17
	YSi	9	8	1	-9	-4
Surmia	Pi	4	3	491	608	686
	Ri	0.22	0.56	0.44	0.56	0.83
	YSi	3	4	-8	8	9
Tonacja	Pi	5	3	306	136	421
	Ri	0.00	0.11	0.50	0.83	0.89
	YSi	1	2	2	13	11
Arizona	Pi	7	4	286	652	1394
	Ri	0.00	0.00	0.56	0.39	0.44
	YSi	-2	0	10	7	5
Lilly	Pi	3	3	199	727	2490
	Ri	0.44	0.33	0.67	0.39	0.17
	YSi	5	-1	11	3	4
Connect	Pi	0	0	380	994	453
	Ri	0.89	1.00	0.50	0.06	0.89
	YSi	9	5	3	2	10
Irmina	Pi	2	1	290	613	2457
	Ri	0.61	0.72	0.50	0.50	0.17
	YSi	8	9	7	6	2
Mariola	Pi	1	0	297	1287	3369
	Ri	0.94	1.00	0.44	0.11	0.06
	YSi	12	11	4	0	-1
Red Lady	Pi	3	2	314	367	221
	Ri	0.22	0.50	0.39	0.61	0.94
	YSi	4	7	8	11	13
Soraya	Pi	6	6	284	453	3067
	Ri	0.00	0.00	0.44	0.67	0,22
	YSi	-1	-6	9	9	1

Pi – feature superiority measure, Ri – Eskridey's feature reliability measure, YSi – Kang's stability measure

2024 – in print). Other studies also emphasized that results of a stability assessment, including those concerning components in tubers, should be used in the search for an optimal variety under different environmental conditions (Flis et al. 2014, Scavo et al. 2023*b*). In the study presented by Scavo et al. (2023*a*), the stability of Arizona variety was emphasized, same as in our study. Additionally, for cultivation in an organic system, tuber varieties should also have elevated resistance to fungal diseases and produce high yields (Przystalski, Lenartowicz 2023).

CONCLUSIONS

Significant influence of the studied factors, i.e. the environment and genotype and their interaction, on the content of all analyzed components in potato tubers was found.

The impact of the environmental factor on shaping the content of components in tubers, from 27.9 to 73.8%, was greater than that of the genotype factor, from 1.9 to 42.7%.

The feature superiority measure (Pi), Eskridge's feature reliability measure (Ri), and Kang's stability measure (YSi) enabled the assessment and distinction of four stable varieties: Mariola, Lilly, Tonacja and Red Lady, stable in terms of the content of basic components in tubers.

The broad adaptation analysis has been shown to be a useful tool for assessing the stability of varieties, guiding breeders in the direction of further research and farmers in the selection of specific genotypes.

Author contributions

Conceptualization, methodology, software, formal analysis, investigation, data curation, writing – original draft, writing – review and editing, resources, visualization, supervision, project administration, funding acquisition.

Conflicts of interest

The author declare no conflicts of interest.

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