ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Agricultura 6(3) 2007, 5-15*

VARIABILITY ANALYSIS OF SELECTED QUANTITATIVE CHARACTERISTICS IN EDIBLE POTATO VARIETIES

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Abstract. The paper presents the variability analysis of some quantitative characteristics, that is of tuber yield, starch content and yield, dry matter content and yield and vitamin C content in selected edible potato varieties. Reciprocal relations of variance components calculated and their percentage share in the total variability were a measure of variability evaluation for the characteristics examined. Moreover, the variability of the characteristics was characterised by means of the classical variability coefficient. It has been found that tuber yield and vitamin C content variability was determined mainly by the interaction effects of years and the factors examined, as well as the experimental error. The respective values were as follows: 44.3% and 34.7% for tuber yield, and 42.2% and 46.2% for vitamin C. The starch content was in 47.5% modified by the effects of the main factors (including 35.0% for years) and the error effect (39.0%). A similar interaction was observed in the case of dry matter content variability, but the error was 52.4%. Starch and dry matter yields were determined mainly by interaction effects of the years and the examined factors (40.7% and 39.9%, respectively) as well as the experimental error (32.2% of the total variability for both traits). The highest changes expressed as the values of the coefficient of variation were found for tuber yield, dry matter yield and starch yield.

Key words: variance components, tuber yield, starch content, dry matter content, vitamin C content, edible potato, variability of characteristics

INTRODUCTION

The characteristics describing potato quality fluctuate substantially. They depend mainly on the variety but also on environmental conditions [Bombik et al. 1996]. The views on the importance hierarchy of the factors influencing tuber yield and chemical composition are generally convergent. It is believed that genotype, followed by the

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environment, exerts the highest influence. Tuber quality is shaped by both natural factors (soil, atmospheric conditions, the course of plant growth and development) and cultural practices (fertilization, planting date, plant cultivation). Fertilization, especially mineral one, is very important as it may substantially change the chemical composition of the tuber. There is also a prominent influence of an interaction of natural as well as cultivation factors and genetic properties of individual varieties [Bombik and Boligłowa 1994].

The share of genotypic and environmental variability differs for particular characteristics, and it can be assessed by means of the variability coefficient, or using the models of variance components which are called random models [Grüneberg et al. 2004]. It is assumed in the models that chiefly main and interaction random effects influence the result of an experiment whereas the population mean is the only constant parameter [Yildrin and Caliscan 1985].

The aim of the paper was to analyse the variability of some quantitative characteristics, that is of tuber yield, starch content and yield, dry matter content and yield and vitamin C content in selected edible potato varieties.

MATERIAL AND METHODS

A three-year field experiment was conducted on the Experimental Farm in Zawady, of the University of Podlasie in Siedlce, on a soil of the rye good complex and quality class IVb. The research period (1999-2001) was characterised by a considerable variability of thermal conditions as well as precipitation distribution and intensity, which is reflected in the values of Sielianinov’s coefficients presented in Table 1.

Table 1. Sielianinov’s coefficient values (k)
Tabela 1. Wartości współczynników Sielaninowa (k)

Year Rok	Month – Miesiąc							Mean for the growing season Średnio dla okresu wegetacyjnego
	III	IV	V	VI	VII	VIII	IX	
1999	0.72	2.94	0.66	1.98	0.32	1.34	0.58	1.22
2000	1.67	1.23	0.48	0.29	2.64	0.74	1.73	1.25
2001	0.77	2.67	0.58	0.70	0.75	0.38	2.98	1.26

$k \leq 0.50$ – strong drought – silna posucha
$0.50 \leq k \leq 0.69$ – drought – posucha
$0.70 \leq k \leq 0.99$ – slight drought – słaba posucha
$k \geq 1$ – no drought – brak posuchy, according to Bac et al. [1993] – według Baca i in. [1993]

The assessment of the weather conditions of the three potato growing seasons allows one to conclude that the 2001 season was the coldest and was characterised by a large amount of precipitation which was unevenly distributed in time.

The experiment was set up in four replications according to the design with complete confounding higher order interaction (s^h) 3^3. The design plan was based on the work by Przybysz [1993].

An influence of the following factors on starch, dry matter and vitamin C content in edible potato tubers was determined:

1) potato variety: A_1 – Aster, A_2 – Muza, A_3 – Ania,

2) mineral fertilizer rate (in kg·ha^{-1}): B_1 – 60 N, 60 P_2O_5, 90 K_2O (NPK), B_2 – 120 N, 120 P_2O_5, 180 K_2O (2NPK), B_3 – 180 N, 180 P_2O_5, 270 K_2O (3NPK),
3) potato forecrop (winter intercrop): C_1 – winter rape, C_2 – a mixture of rye and hairy vetch, C_3 – rye.

Directly after harvest potato tuber yield was assessed and the starch content in the tubers was determined on the Reiman-Parov scales. The dry matter and vitamin C contents were determined by the oven drying gravimetric method and the Tillmans method, respectively.

The results obtained were analysed by means of the variance analysis appropriate for the 3^3 confounded design. The percentage structure of variance components estimates was the basis of the analysis of an influence of years, varieties, mineral fertilization and forecrops. Models of variance components are applied when the levels of investigated factors are populative in character whereas the actually considered levels constitute a random sample taken from this population [Oktaba 2000]. In the models, apart from the population mean (m) which is a constant parameter, the value of a characteristic is influenced by main and interaction random effects which, it is assumed, have got independent normal distributions with zero means and the same variances (σ^2). Moreover, independence of the effects of various kinds is assumed. The major aim of an estimation of variance components is to estimate the population covariance between random factors and an independent variable. The scheme of variance analysis table for a random model, according to which the values of variance components were estimated, is shown in Table 2.

Empirical values of mean squares from the analysis of variance were compared to their expected values, and estimates of variance components, being the best credibility estimates, were obtained [Gordon et al. 1972, Ubysz-Borucka et al. 1985, Oktaba 2000]. The values of negative estimates from calculations were “artificially” zeroed. The hypotheses assuming that the variances of these components equal zero were not checked [Rao 1972, Lamotte 1973, Trętowski et al. 1989, Starczewski et al. 1996, Milewska 1998]. The relations of the variance components estimates and their percentage structure were a basis to assess an influence of the examined factors on the variability of edible potato quantitative characteristics which were studied. The variability of characteristics in individual varieties was also estimated by means of the classical variability coefficient.

RESULTS AND DISCUSSION

The variability of the characteristics examined in individual edible potato varieties is presented in Tables 3 and 4, and the percentage share of variance components is shown in Figure 1.

The variability of tuber yield in the experiment to a large extent (in 34.7% of total variability) depended on the experimental error (Figure 1). The share of the error in the total variability of this characteristic may substantially fluctuate form about 23.0% [Trętowski et al. 1989] to about 50.0% of the total variability [Bombik and Boligłowa 1994].

Table 2. Scheme of variance analysis for a random model
Tabela 2. Schemat analizy wariancji dla modelu losowego

Sources of variation – Źródła zmienności	Degrees of freedom Stopnie swobody	Expected values of mean squares – Wartości oczekiwane średnich kwadratów
Years (L) – Lata (L)	l-1	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + bn\sigma_{lac}^2 + cn\sigma_{lab}^2 + abn\sigma_{lc}^2 + acn\sigma_{bl}^2 + bcn\sigma_{la}^2 + abcn\sigma_l^2$
Variety (A) – Odmiany (A)	a-1	$\sigma_e^2 + n\sigma_{labc}^2 + bn\sigma_{lac}^2 + cn\sigma_{lab}^2 + ln\,\sigma_{abc}^2 + b\,ln\,\sigma_{ac}^2 + c\,ln\,\sigma_{ab}^2 + bcn\sigma_{la}^2 + bc\,ln\,\sigma_a^2$
Fertilization (B) – Nawożenie (B)	b-1	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + cn\sigma_{lab}^2 + ln\,\sigma_{abc}^2 + a\,ln\,\sigma_{bc}^2 + c\,ln\,\sigma_{ab}^2 + acn\sigma_{lb}^2 + ac\,ln\,\sigma_b^2$
Forecrop (C) – Przedplon (C)	c-1	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + bn\sigma_{lac}^2 + ln\,\sigma_{abc}^2 + a\,ln\,\sigma_{bc}^2 + b\,ln\,\sigma_{ac}^2 + abn\sigma_{lc}^2 + ab\,ln\,\sigma_c^2$
Years x variety (L x A) – Lata x odmiany (L x A)	(l-1) (a-1)	$\sigma_e^2 + n\sigma_{labc}^2 + bn\sigma_{lac}^2 + cn\sigma_{lab}^2 + bcn\sigma_{la}^2$
Years x fertilization (L x B) – Lata x nawożenie (L x B)	(l-1) (b-1)	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + cn\sigma_{lab}^2 + acn\sigma_{lb}^2$
Years x forecrop (L x C) – Lata x przedplon (L x C)	(l-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + bn\sigma_{lac}^2 + abn\sigma_{lc}^2$
Variety x fertilization (A x B) – Odmiany x nawożenie (A x B)	(a-1) (b-1)	$\sigma_e^2 + n\sigma_{labc}^2 + cn\sigma_{lab}^2 + ln\,\sigma_{abc}^2 + c\,ln\,\sigma_{ab}^2$
Variety x forecrop (A x C) – Odmiany x przedplon (A x C)	(a-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + bn\sigma l_{lac}^2 + dn\sigma_{abc}^2 + adn\sigma_{ac}^2$
Fertilization x forecrop (B x C) – Nawożenie x przedplon (B x C)	(b-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + an\sigma_{lbc}^2 + ln\,\sigma_{abc}^2 + a\,ln\,\sigma_{bc}^2$
Years x variety x fertilization (L x A x B) Lata x odmiany x nawożenie (L x A x B)	(l-1) (a-1) (b-1)	$\sigma_e^2 + n\sigma_{labc}^2 + cn\sigma_{lab}^2$
Years x variety x forecrop (L x A x C) Lata x odmiany x przedplon (L x A x C)	(l-1) (a-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + bn\sigma_{lac}^2$
Years x fertilization x forecrop (L x B x C) Lata x nawożenie x przedplon (L x B x C)	(l-1) (b-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + bn\sigma_{lbc}^2$
Variety x fertilization x forecrop (A x B x C) Odmiany x nawożenie x przedplon (A x B x C)	(a-1) (b-1) (c-1)	$\sigma_e^2 + n\sigma_{labc}^2 + ln\,\sigma_{abc}^2$
Years x variety x fertilization x forecrop (L x A x B x C) Lata x odmiany x nawożenie x przedplon (L x A x B x C)	(l-1) (a-1) (b-1) (c-1) (d-1)	$\sigma_e^2 + n\sigma_{labc}^2$
Error – Błąd	(n-1) (ł-h)	σ_e^2

ł – number of combinations s^h – liczba kombinacji s^h, h – number of sub-blocks – liczba podbloków, n – number of replications – liczba powtórzeń, a – number of varieties (A) – liczba odmian (A), b – number of mineral fertilization levels (B) – liczba poziomów nawożenia mineralnego (B), c – number of forecrops (C) – liczba przedplonów (C); $\sigma_e^2, \sigma_{labc}^2, \sigma_{abc}^2, \sigma_{lbc}^2, \sigma_{lac}^2, \sigma_{lab}^2, \sigma_{bc}^2, \sigma_{ac}^2, \sigma_{ab}^2, \sigma_{lc}^2, \sigma_{lb}^2, \sigma_{la}^2, \sigma_c^2, \sigma_b^2, \sigma_a^2, \sigma_l^2$ – respective variance components – odpowiednie komponenty wariancyjne

Table 3. Characterization of the characteristics variability of edible potato varieties
Tabela 3. Charakterystyka zmienności cech odmian ziemniaka jadalnego

Quality characteristics of potato tubers Cechy jakości bulw ziemniaka	Statistical measures Miary statystyczne	Variety – Odmiana		
		Aster	Muza	Ania
Tuber yield Plon bulw $t \cdot ha^{-1}$	Arithmetic mean Średnia arytmetyczna	30.9	33.7	35.1
	Variability range Zakres zmienności	28.3-32.6	35.9-38.9	28.0-41.9
	Variability coefficient, % Współczynnik zmienności,%	17.1	15.2	15.1
Starch content Zawartość skrobi %	Arithmetic mean Średnia arytmetyczna	13.9	14.4	14.5
	Variability range Zakres zmienności	12.7-14.8	13.5-15.1	13.4-14.9
	Variability coefficient, % Współczynnik zmienności, %	6.4	6.2	6.1
Dry matter content Zawartość suchej masy %	Arithmetic mean Średnia arytmetyczna	21.0	21.7	21.0
	Variability range Zakres zmienności	19.3-22.5	20.9-22.9	19.3-22.4
	Variability coefficient, % Współczynnik zmienności, %	8.3	8.1	8.3
Vitamin C content Zawartość witaminy C mg%	Arithmetic mean Średnia arytmetyczna	21.8	21.9	21.5
	Variability range Zakres zmienności	20.2-23.9	20.0-21.2	21.9-24.5
	Variability coefficient, % Współczynnik zmienności, %	13.7	13.5	13.9
Starch yield Plon skrobi $t \cdot ha^{-1}$	Arithmetic mean Średnia arytmetyczna	4.3	5.4	4.1
	Variability range Zakres zmienności	3.6-4.9	4.7-5.7	3.9-4.0
	Variability coefficient, % Współczynnik zmienności, %	17.3	15.2	19.9
Dry matter yield Plon suchej masy $t \cdot ha^{-1}$	Arithmetic mean Średnia arytmetyczna	6.3	6.9	7.2
	Variability range Zakres zmienności	5.3-7.2	5.9-7.7	5.4-9.4
	Variability coefficient, % Współczynnik zmienności, %	21.7	19.5	18.9

The characteristic much less depended on fertilization and variety. An interesting phenomenon was the fact that tuber yield was not markedly modified by the research years (9.2%). This result differs very much from the result obtained by Trętowski et al. [1989] who reports that research years can determine tuber yield variability in as much as 75.0%. The effect of years was revealed in their interaction with the investigated factors, and it constituted 44.3% of the total variability, 23.5% being an effect of years x varieties (Table 4). This interaction proves that changes in the yield level caused by the pattern of environment natural conditions were not the same for all the varieties. The tuber yield variability, expressed in the value of the variability coefficient, was higher in the Aster variety than in Muza and Ania (Table 3).

Table 4. Variance components of some characteristics of edible potato for the factors examined and their interactions
Tabela 4. Komponenty wariancyjne niektórych cech ziemniaka jadalnego dla badanych czynników i ich interakcji

Variance component Komponent wariancyjny	Examined characteristic – Badana cecha											
	Tuber yield Plon bulw		Starch content Zawartość skrobi		Dry matter content Zawartość suchej masy		Vitamin C content Zawartość witaminy C		Starch yield Plon skrobi		Dry matter yield Plon suchej masy	
σ^2_l	7.45	(9.2)	0.709	(35.0)	1.50	(25.6)	0.0505	(0.3)	0.375	(18.6)	0.983	(17.3)
σ^2_a	3.20	(3.9)	0.0485	(2.4)	0.330	(5.6)	0.665	(3.4)	0.117	(5.8)	0.326	(5.7)
σ^2_{la}	19.1	(23.5)	0.0557	(2.7)	0.000	(0.0)	4.830	(24.9)	0.517	(25.6)	1.37	(24.1)
σ^2_b	4.75	(5.9)	0.179	(8.8)	0.0286	(0.5)	1.059	(5.5)	0.0350	(1.7)	0.113	(2.0)
σ^2_{lb}	4.97	(6.1)	0.0146	(0.7)	0.0653	(1.1)	1.050	(5.4)	0.0632	(3.1)	0.170	(3.0)
σ^2_c	0.00	(0.0)	0.000694	(0.0)	0.000	(0.0)	0.00	(0.0)	0.000	(0.0)	0.000	(0.0)
σ^2_{lc}	2.69	(3.3)	0.000	(0.0)	0.0647	(1.1)	0.300	(1.5)	0.0626	(3.1)	0.0840	(1.5)
σ^2_{ab}	0.613	(0.8)	0.000	(0.0)	0.189	(3.2)	0.308	(1.6)	0.0102	(0.5)	0.126	(2.2)
σ^2_{lab}	6.22	(7.7)	0.0625	(3.1)	0.000	(0.0)	1.786	(9.2)	0.0300	(1.5)	0.411	(7.2)
σ^2_{ac}	0.933	(1.2)	0.00	(0.0)	0.0283	(0.5)	0.00	(0.0)	0.00734	(0.4)	0.000	(0.0)
σ^2_{lac}	2.99	(3.7)	0.0367	(1.8)	0.378	(6.5)	0.00	(0.0)	0.000	(0.0)	0.235	(4.1)
σ^2_{bc}	0.000	(0.0)	0.00	(0.0)	0.000	(0.0)	0.157	(0.8)	0.00190	(0.1)	0.0231	(0.4)
σ^2_{lbc}	0.000	(0.0)	0.0850	(4.2)	0.0483	(0.8)	0.00	(0.0)	0.000	(0.0)	0.000	(0.0)
σ^2_{abc}	0.000	(0.0)	0.0258	(1.3)	0.103	(1.8)	0.00	(0.0)	0.000	(0.0)	0.0150	(0.3)
σ^2_{labc}	0.000	(0.0)	0.0200	(1.0)	0.055	(0.9)	0.228	(1.2)	0.150	(7.4)	0.000	(0.0)
σ^2_e	28.2	(34.7)	0.790	(39.0)	3.07	(52.4)	8.99	(46.2)	0.650	(32.2)	1.830	(32.2)

percentages are given in brackets – w nawiasach podano wartości procentowe

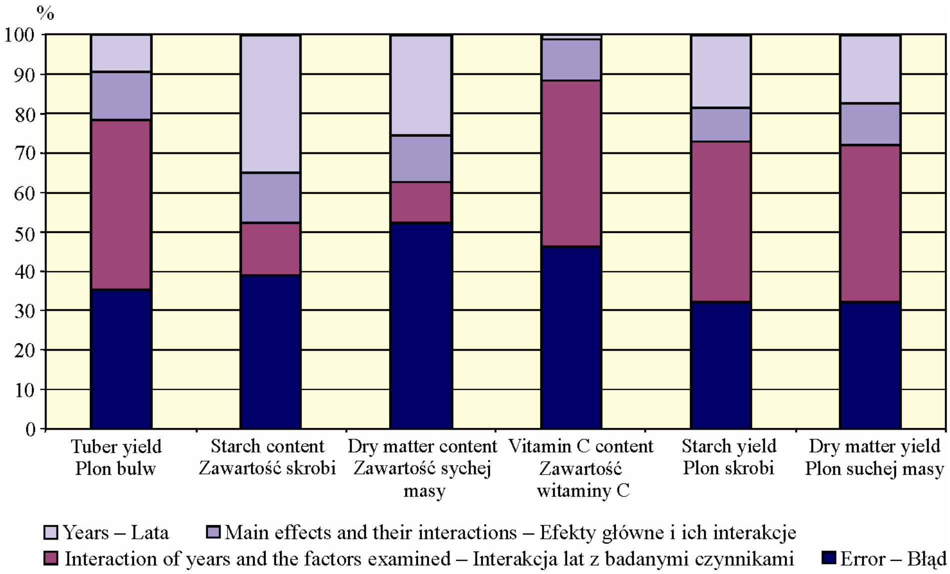

Fig. 1. Variance components structure of yield and edible potato tuber quality characteristics
Rys. 1. Struktura komponentów wariancyjnych plonu i cech jakościowych bulw ziemniaka jadalnego

Starch content is a varietal characteristic, and in edible potato tubers, it ranges from 12.0 to 16.0% [Zgórska and Frydecka-Mazurczyk 1996]. Also Gislason et al. [1984], Bombik and Boligłowa [1994], Mazurczyk [1994] and Wojnowska et al. [1998] point to the genotype as the factor which most strongly determines the starch content. The starch amount depends not only on genetic properties of a variety but also on photosynthesis intensity and on how long it lasts [Gąsior and Paśko 1998, Schäfer-Pregl et al. 1998]. That is why warm and sunny weather stimulates starch accumulation in tubers [Leszczyński 1994]. The content of this component in the research discussed was most strongly determined by the error (39.0%). A large percentage of variability (35.0%) was associated with the effect of years (Figure 1). The effects of varieties, fertilization and forecrops amounted to 11.2% of the total variability. On the basis of Table 4 it can be interfered that, among the interaction effects, the interaction of years, fertilization and forecrop as well as the interaction of years, varieties and mineral fertilization constituted the highest percentage (4.2% and 3.1%, respectively). The starch content variability oscillated around 6.0%, and was the highest for early variety Aster. The smallest variability of starch content was found for the medium-late Ania variety (Table 3).

The pattern of weather conditions over the growing period is a factor that significantly diversifies the dry matter content [Puła and Skowera 2004]. Its value to a large degree depends on the starch content and, according to Wojdyła [1997], is a genetic trait. Edible potatoes contain 15.0 to 32.0% of dry matter [Zgórska and Frydecka-Mazurczyk 1996]. In the experiment discussed the variability caused by the genotype was at the level of 5.6%. In contrast, the random effect and the years most strongly modified this characteristic (52.4% and 25.6%, respectively). Interaction effects of the years and investigated factors constituted 13.5% of the total variability (Figure 1, Table 4). In the varieties examined the content of this component ranged from

13.9% in the Aster variety to 14.5% in the Ania variety. The variability of this characteristic in the varieties studied oscillated around 8% and was the smallest for the Muza variety

The vitamin C level in tubers is very changeable [Sinden et al. 1978] and, according to Rogozińska [1983], Sawicka [1987], Komorowska-Jędrys [1997] and Danilczenko et al. [2000], depends mainly on the variety. Mineral fertilization is another factor which changes ascorbic acid content in tubers although Roztropowicz [1989] reports on increasing nitrogen rates reducing vitamin C content, which, however, cannot always be proved. In the experiment conducted this characteristic was mostly determined by the error effect (44.7%). The interaction effects of years and the investigated factors had a little smaller share in the total variability (42.2%), half of which being induced by the interaction of years and varieties (24.9%). The main factors in 8.9% determined the vitamin C variability (variety effect was 3.4%, mineral fertilization effect was 5.5%). Growing season effects were close to zero (0.3%) whereas the forecrop effect equalled zero (Fig. 1, Table 4). The vitamin C content was the lowest in Ania tubers and the highest in the tubers of Muza variety in which the variability of the characteristic discussed was the highest (Table 3).

The starch yield is influenced by the tuber weight and its percentage content in tubers. Kosecka et al. [1989] have proven that fertilization to the level of 100 kg $N \cdot ha^{-1}$ increases the starch yield whereas the rate of over 200 kg $N \cdot ha^{-1}$ reduces it. On the basis of Table 4 and Figure 1 it can be interfered that the starch yield in the research years was first and foremost conditioned by the interaction effect of years and investigated factors (40.7%) as well as the random error which constituted 32.2% of the total variability. Growing seasons, main effects and their interactions in 18.6 and 8.5% (including 5.8% for the genotype and 1.7% for fertilization), respectively, modified the starch yield. The starch yield variability was the smallest for the Muza variety and the highest for the Aster variety (Table 3).

The dry matter yield, similarly to the starch yield, is the result of interplay of tuber yield and dry matter percentage content. The dry matter yield variability in the tubers of the varieties examined, just like in the case of starch content, depended chiefly on the interaction effects of years and investigated factors (the effects constituted 39.9% of the total variability), and the experimental error (32.2%). The years and main effects much less significantly determined the dry matter yield, that is in 17.3% and 7.7%, respectively (Table 4, Figure 1).

CONCLUSIONS

1. To sum up, it can be said that the variance components discussed in the present work may be used to draw various conclusions on an influence of individual factors and their interactions on the variability of the quantitative characteristics examined. Thus the method is suitable to estimate a response of edible potato to some elements of cultivation and environmental conditions. The method applied and the results obtained limit, in a sense, the possibility of generalization due to a small number of factorial treatments which were analyzed.

2. Moreover, it was found that the variability of all the investigated characteristics was determined chiefly by the interaction effects of years and examined factors, as well as the error effect, which is especially visible in the case of tuber yield, dry matter yield

and vitamin C content. The research years, which reflect an influence of weather conditions in the growing season, most strongly affected the starch content, dry matter content, starch yield and dry matter yield. Tuber yield and the characteristics related to it, that is starch yield and dry matter yield, underwent the most prominent changes.

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ANALIZA ZMIENNOŚCI WYBRANYCH CECH ILOŚCIOWYCH U ODMIAN ZIEMNIAKA JADALNEGO

Streszczenie. W pracy przedstawiono analizę zmienności niektórych cech ilościowych, tj. plonu bulw, zawartości i plonu skrobi, zawartości i plonu suchej masy oraz zawartości witaminy C u wybranych odmian ziemniaka jadalnego. Miarą oceny zmienności badanych cech były wzajemne relacje wyznaczonych ocen komponentów wariancyjnych ich oraz procentowy udział w zmienności całkowitej. Zmienność badanych cech scharakteryzowano, korzystając z klasycznego współczynnika zmienności. Wykazano, że zmienność plonu bulw i witaminy C determinowana była głównie przez efekty interakcyjne lat z badanymi czynnikami i błąd doświadczalny. Wartości te wynosiły odpowiednio: 44,3% i 34,7% dla plonu bulw oraz 42,2% i 46,2% dla witaminy C. Zawartość skrobi modyfikowana była w 47,5%, przede wszystkim przez efekty czynników głównych (w tym lat 35,0%) i efekt błędu (39,0%). Podobną reakcję odnotowano w przypadku zmienności zawartości suchej masy, z tym że błąd stanowił 52,4%. Plon skrobi i suchej masy determinowany był głównie przez efekty interakcyjne lat z badanymi czynnikami (odpowiednio: 40,7% i 39,9%) oraz błąd doświadczalny (po 32,2% zmienności całkowitej). Największym zmianom, wyrażonym w postaci współczynnika zmienności, podlegał plon bulw, suchej masy i skrobi.

Słowa kluczowe: komponenty wariancyjne, plon bulw, zawartość skrobi, zawartość suchej masy, zawartość witaminy C, ziemniak jadalny, zmienność cech

Accepted for print – Zaakceptowano do druku: 15.12.2007