Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2004
Volume 7
Issue 1
Series HORTICULTURE

BRAUN-MŁODECKA U. 2004. GENETIC IMPROVEMENT OF GLOBOSE AND SLIGHTLY FLATTENED CULTIVARS OF RED GARDEN BEET LISTED IN POLAND BETWEEN 1988 AND 1999 **Electronic Journal of Polish Agricultural Universities**, Horticulture, Volume 7, Issue 1.
Available Online http://www.ejpau.media.pl

GENETIC IMPROVEMENT OF GLOBOSE AND SLIGHTLY FLATTENED CULTIVARS OF RED GARDEN BEET LISTED IN POLAND BETWEEN 1988 AND 1999

Urszula Braun-Młodecka
Department of Seed Science, Technology and Nursery Production,
August Cieszkowski Agricultural University of Poznań, Poland

ABSTRACT

The paper aimed at estimating the genetic improvement in yield and some quality traits of globose and slightly flattened cultivars of red garden beet listed in Poland during the years 1988-1999. The method of deviations from a check was used. The calculations were based on the results of cultivar testing conducted by the Research Centre for Cultivar Testing in Słupia Wielka. A significant genetic improvement of 0.55%/yr. was achieved in marketable yield. The genetic gain in betanin content amounted to 0.78%/yr. and vulgaxanthine to 1.33%/yr. However, the content of dry matter decreased at an annual rate of –0.77% and of sugar at the rate of -1.12%/yr. The content of nitrates negatively increased by 0.74%/yr. Depending on the trait analysed approximately 17% - 30% of the total improvement could be attributed to genetic factors.

Key words: red garden beet, genetic improvement, cultivar

INTRODUCTION

Red garden beet is one of the four most important vegetables in Poland together with white cabbage, carrot and onion. Globose and slightly flattened cultivars dominate the production. Cultivars with elongated roots, however, are of less significance. The vegetable can be used for culinary purposes and food colorants [11]. Its usefulness is determined by the morphological characteristics of roots [12, 13] as well as by the content of dry matter, sugar, pigments and nitrates [11]. These traits were assessed for listing purposes [9]. Moreover, the results of chemical and technological analyses influenced the decision on entering national lists [9]. Bruch-Kowalska and Pędziński [3] stated that the breeding work on red garden beet had been accelerated in Poland. Hitherto the genetic improvement of the crop in Poland was characterised by means of descriptive analyses only [1, 2].

The paper aimed at evaluating the genetic improvement in yield and a few quality traits of globose and slightly flattened cultivars of red garden beet listed in Poland in the twelve-year period of 1988-1999 by means of mathematical methods.

MATERIALS AND METHODS

The analyses of the genetic improvement were based on the national lists (NLs) [7] and the results of cultivar testing conducted from 1988 to 1999 by Experimental Stations for Variety Testing and Chemical-Technological Laboratory in Słupia Wielka and published in "Summarized Results of Varietal Experiments" [8]. Twelve globose and slightly flattened cultivars (seven of Polish origin and five of foreign origin) of red garden beet were included in the analyses. The genetic gain was estimated in yield and some quality traits, i.e. the content of dry matter, sugar, betanin, vulgaxanthine and nitrates.

To estimate the percent genetic progress due to the introduction of new cultivars the method of deviations from the check by Feyerherm et al. [4] was modified and used. The cultivar Czerwona Kula having no gaps in the results of testing over the period analysed and being on the NLs since 1961 was the check. For each cultivar having at least two-year results comparable to the check relative deviations from the check cultivar Czerwona Kula (DC_i) were computed as follows:

$$DC_i = \frac{\sum_{y=1}^{n}\left({V_{CTy}}/{V_{CHECKy}} \cdot 100 \right)}{n} - 100\ [\%],$$

where V_{CTy} indicates the value of the cultivar i in the year y, V_{CHECKy} – value of the check in the year y and n – number of years.

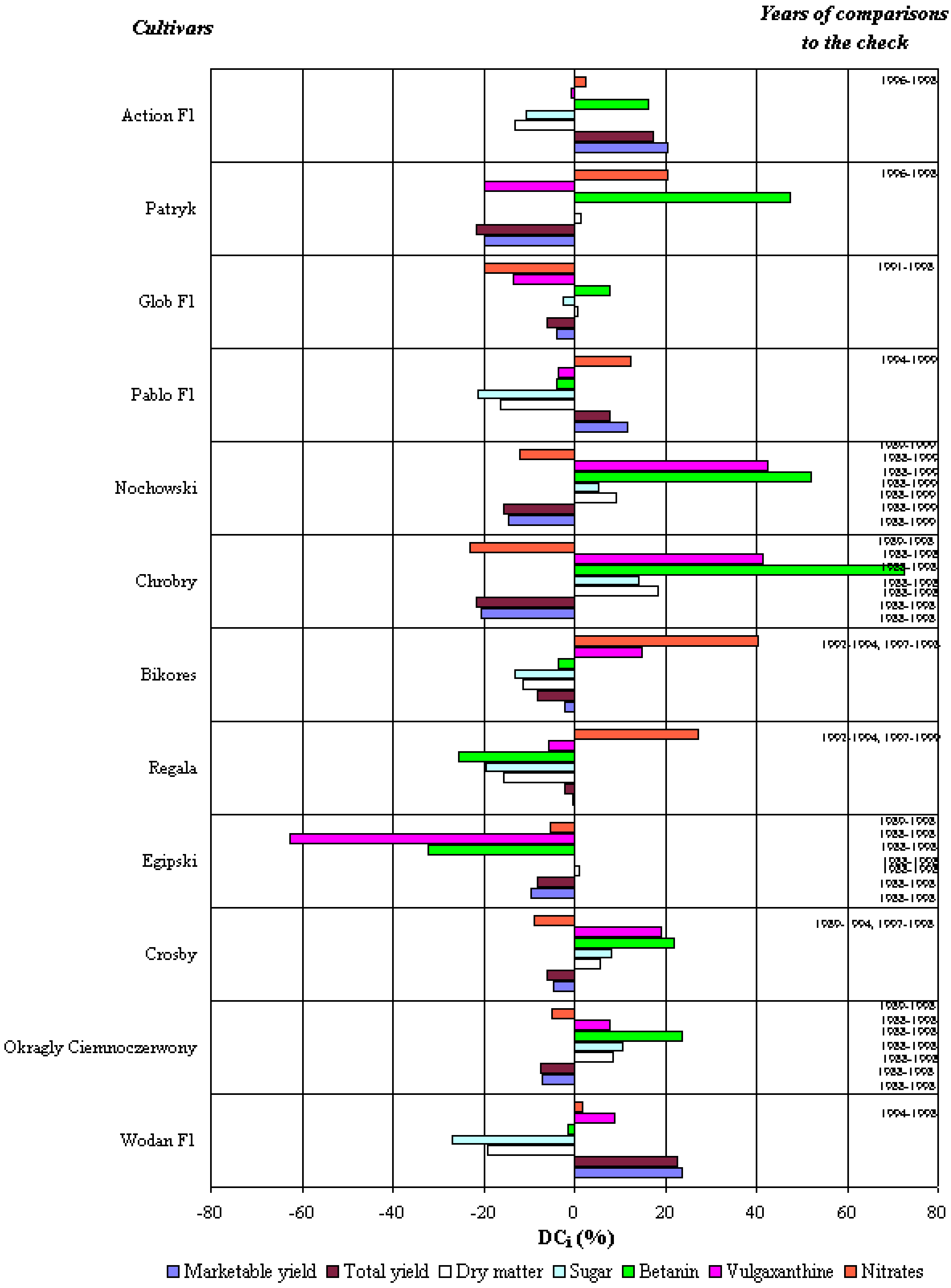
Figure 1 shows the deviations for the cultivars ordered according to the year of their introduction on the NLs [7].

Genetic progress was computed for the consecutive years (P_{Gy}) for listed cultivars excluding the check as follows:

$$P_{Gy} = \frac{\sum_{i=1}^{n}(DC_i)}{n} - \frac{\sum_{i=1}^{n-1}(DC_i)}{n-1}\ [\%],$$

where n indicates the number of cultivars analysed in the year y and $n\text{-}1$ – the number of cultivars analysed in the previous year ($y\text{-}1$)

Fig. 1. Deviations from the check for globose and slightly flattened cultivars of red garden beet



The results obtained in that way denote the changes in the genetic potential due to the introduction of new cultivars in a given year as compared to the previous year.

The results of the testing of the check cultivar Czerwona Kula and the P_{Gy} values were regressed on years. The coefficient *b* of the linear regression: $y = bx + a$, denotes the annual variation due to environment and genetic factors respectively. The share of the improvement attributable to genetic factors in total variability was calculated as the ratio of the annual variation due to genetic factors (i.e. *b* value for P_{Gy}), and summarized variation due to genetic and environmental factors (i.e. *b* value for P_{Gy} + *b* value for the check) and expressed as percentage.

The coefficient *b* for each regression equation was evaluated for the difference from zero at 0.05, 0.01 and 0.001 probability levels by means of the statistical packages Genstat 5 and Minitab [5, 10].

RESULTS

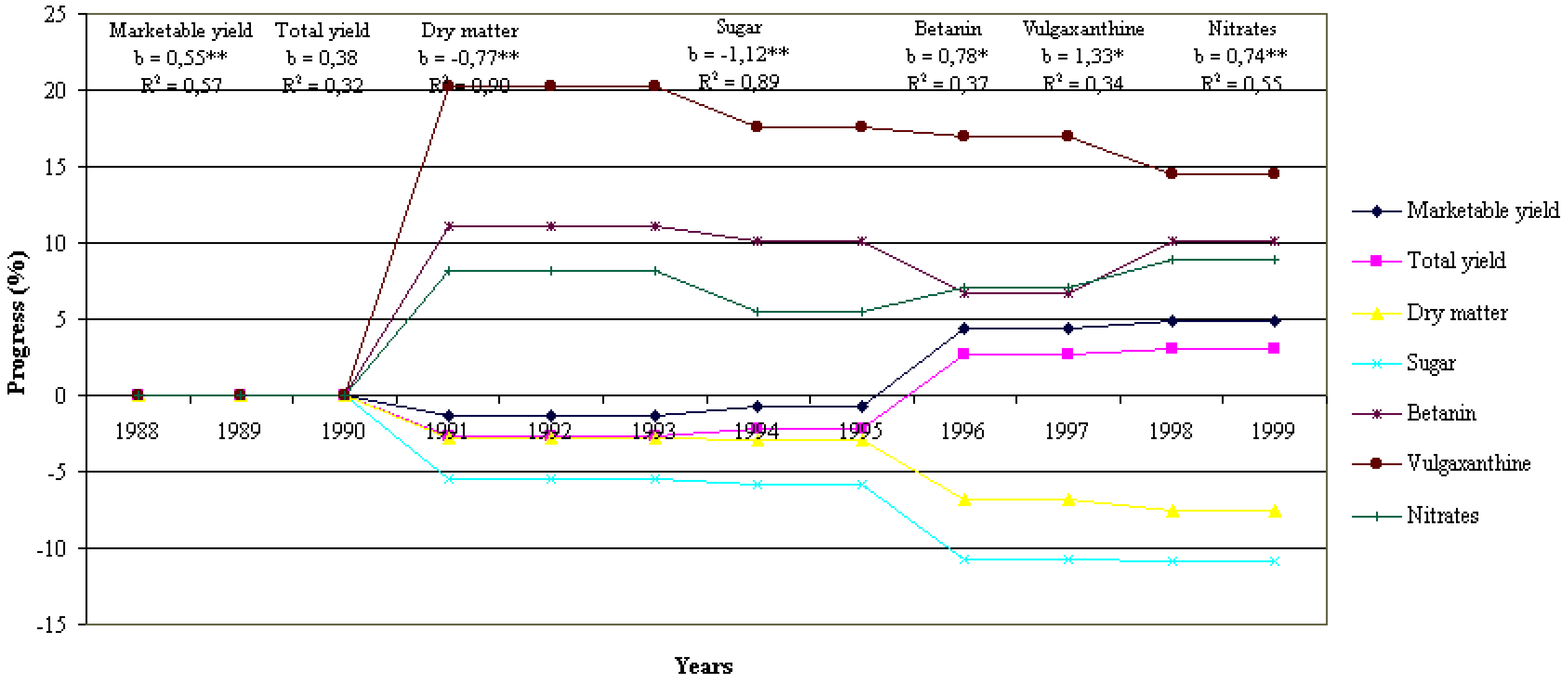
Over the twelve – year period of 1988-1999 there were no changes of the genetic potential of globose and slightly flattened cultivars of red garden beet in Poland in 1988, 1989, 1990, 1992, 1993, 1995, 1997 and 1999 due to the lack of new entries.

In the year 1991 two Polish cultivars Chrobry and Nochowski and two cultivars Regala and Bikores of foreign origin entered the NL. Their introduction yielded in decreases in marketable (–1.30%) and total yield (–2.70%), the content of dry matter (–2.75%) and sugar (–5.43%). However the content of betanin increased by 11.09%, vulgaxanthine – by 20.21% and nitrates – by 8.23%. In 1994 the Polish cultivar Glob contributed to increases of the genetic potential in both marketable (by 0.58%) and total yield (by 0.50%) and decreases in the content of dry matter (by –0.19%), sugar (by –0.39%), betanin (by –0.98%), vulgaxanthine (by –2.70%) and nitrates (by –2.71%). Two Dutch hybrids Pablo and Wodan were introduced in 1996. Their genetic value further improved marketable (5.08%) and total yield (4.90%). The content of nitrates increased by 1.57%. Decreases were noted in the content of dry matter (3.93%), sugar (4.86%), betanin (3.46%) and vulgaxanthine (0.53%). The introduction of the cultivars Patryk (of Polish origin) and Action (of foreign origin) in 1998 improved marketable and total yield by 0.50 and 0.38% respectively. Additionally, the genetic potential in the content of betanin increased by 3.47%. Negative changes, however, comprised an increase in the content of nitrates (by 1.80%) and decreases in the content of dry matter (by –0.68%), sugar (by –0.14%) and vulgaxanthine (by –2.52%).

In the analysed period marketable yield increased at an annual rate of 0.55% (significant at $p \leq 0.01$). The content of both betanin and vulgaxanthine also increased significantly at the rates of 0.78%/yr. and 1.33%/yr. respectively. The content of nitrates increased by 0.74%/yr. on average. In contrast, the content of dry matter and sugar decreased at the rates of –0.77%/yr. and –1.12%/yr. respectively (fig. 1).

Introduction of three Polish and three foreign cultivars to a set of three older cultivars (Okrągły Ciemnoczerwony, Crosby and Egipski) brought about the changes of the genetic potential. Among the cultivars included in the analyses, a cultivar owned by Bejo Zaden B.V. contributed most of all to the increase in yield and cultivars coming from SPÓJNIA Hodowla Roślin i Nasiennictwo Ogrodnicze Sp. z o.o. displayed the highest content of dry matter, sugar, pigments and the lowest – of nitrates (fig. 2).

Fig. 2. Genetic improvement in yield and a few quality traits of globose and slightly flattened cultivars of red garden beet listed in Poland in 1988-1999



The changes of the check cultivar were fully attributed to environmental factors (tab. 1). Thus approximately 29.6% of the total improvement in marketable yield and 20.5% – in total yield, 17.4% – in the content of betanin and 26.4% – vulgaxanthine as well as over 88% of the decrease in dry matter could be attributed to genetic factors. But the regression coefficients expressing the changes due to environment were not significant except for the content of betanin. For the content of sugar genetic and environmental factors played opposite role. The content increased due to environmental factors at the rate of 1.5%/yr. and decreased as a result of genetic ones by –1.12%/yr. Similarly, opposite action of environmental and genetic factors was noted in nitrates from 1989 to 1999. The coefficient *b* expressing the change of the genetic potential was 0.65 (significant at $p \leq 0.05$, R^2 = 0.44).

Table 1. Characteristics of the check cultivar Czerwona Kula

Trait	Years	Mean	Unit	Changes in years				Annual variation due to environmental factors (*b**100/Mean), %
				min.	max.	*b*	R^2	
Marketable yield	1988-1999	564.4	dt ha^{-1}	413	679	7.45	0.09	1.31
Total yield	1988-1999	601.1	dt ha^{-1}	413	740	8.86	0.14	1.47
Dry matter	1988-1999	15.07	% of fresh weight	11.5	17.0	-0.015	0.00	-0.10
Sugar	1988-1999	10.70	% of fresh weight	9.0	13.4	0.161	0.23	1.50
Betanin	1988-1999	0.168	% of extract	0.12	0.24	0.0062*	0.36	3.70
Vulgaxanthine	1988-1999	0.116	% of extract	0.07	0.24	0.0043	0.21	3.71
Nitrates	1989-1999	1873	mg of NO_3^-/kg of fresh weight	980	2658	-21.36	0.03	-1.14

Explanations:
b – coefficient of the linear regerssion $y = bx + a$,
R^2 – coefficient of determination,
* – coefficient *b* significantly different from zero at $p \leq 0.05$.

Environmental factors contributed to increases in yield of ca. 1.5%/yr. and in pigments of 3.7%/yr. as well as decreased the content of nitrates by 1%/yr. (tab. 1).

DISCUSSION

The present paper attempts to estimate the genetic improvement of globose and slightly flattened cultivars of red garden beet by means of mathematical methods. The calculations showed a significant genetic improvement of 0.55%/yr. in marketable yield in the years 1988-1999. Similarly, Grandillo et al. [6] noted an increase in yield of processing tomatoes amounting to 0.44%/yr. in Israel in the period of 1975-1995. The improvement in yield can be attributed to the breeding work aiming at increasing the resistance to biotic and abiotic stresses [14] and to the effect of heterosis (four out of nine newly introduced cultivars included in the present analyses were hybrids).

Decreases in the content of dry matter and sugar were noted in the genetic potential of globose and slightly flattened cultivars of red garden beet listed in the twelve-year period. In the calculations by Grandillo et al. [6] also the improvement in yield was accompanied by a reduction in the content of dry matter. Saliba-Colombani et al. [15], however, examining 144 inbred lines obtained by crossing *Lycopersicon esculentum* Mill. and *Lycopersicon esculentum* var. *cerasiforme*, noted a negative correlation between yield and dry matter weight and a positive one between dry matter weight and sugar content.

In the present analyses significant increases of the content of betanin (0.78%/yr.) and vulgaxanthine (1.33%/yr.) were observed. The improvement can be mainly attributed to the genetic value of Chrobry and Nochowski. Żuradzka et al. [16] stated that not only the total content of the pigments is important but also their ratio.

Approximately 17-30% of the total changes in yield and quality traits in Poland were attributable to the genetic value of the cultivars analysed. According to Grandillo et al. [6] 20% of the total improvement in processing tomatoes in Israel from 1975 to 1995 was attributable to genetic factors while in California from 1977 to 1987 –

60%. In California during the period of 1989-1994 genetic factors improved brix yield and environmental – decreased it [6]. In the present investigations, such an opposite action of genetic and environmental factors was found for the content of sugar and nitrates.

CONCLUSIONS

For the analysed group of red garden beet in the period 1988-1999 significant improvement due to introduction of new cultivars was achieved in marketable yield and the content of pigments.
Unsatisfactory changes comprised decreases in the content of dry matter and sugar and an increase in the content of nitrates.
Depending on the trait 17-30% of the total variation could be attributed to genetic factors.

REFERENCES

1. Analiza postępu w hodowli roślin uprawnych w Polsce 1986-1990, 1991 [Analysis of the progress in plant breeding in Poland from 1986 to 1990]. Wiadomości Odmianoznawcze. COBORU, Słupia Wielka, zeszyt 43 [in Polish].
2. Analiza postępu w hodowli roślin uprawnych w Polsce 1991-1994, 1995 [Analysis of the progress in plant breeding in Poland from 1991 to 1994]. Wiadomości Odmianoznawcze. COBORU, Słupia Wielka, zeszyt 60 [in Polish].
3. Bruch-Kowalska M., Pędziński M., 1996. Hodowla nowych odmian buraków ćwikłowych w SPÓJNI Nochowo [Breeding of new cultivars of red garden beet in SPÓJNIA Nochowo]. VI Ogólnopolski Zjazd Hodowców Roślin Ogrodniczych "Hodowla Roślin o Podwyższonej Jakości. Kraków, 15-16 lutego 1996, 364-367 [in Polish].
4. Feyerherm A. M., Paulsen G. M., Sebaugh J. L., 1984. Contribution of genetic improvement to recent wheat yield increases in the USA, Agronomy Journal 76, 985-990.
5. Genstat 5 Reference Manual. Genstat 5 Committee, 1989. Oxford University Press, United Kingdom.
6. Grandillo S., Zamir D., Tanksley S. D., 1999. Genetic improvement of processing tomatoes; a 20 years perspective. Euphytica 110, 85-97.
7. Lista odmian roślin warzywnych 1988-1999 [List of Vegetable Cultivars]. COBORU, Słupia Wielka [in Polish].
8. Litka M., 1989-2000. Syntezy wyników doświadczeń odmianowych. Warzywa korzeniowe [Summarized Results of Varietal Experiments. Rooted Vegetables]. COBORU, Słupia Wielka [in Polish].
9. Litka M., 1996. Wartość odżywcza warzyw w ocenie COBORU [Nutritional value of vegetables in the COBORU assessment]. VI Ogólnopolski Zjazd Hodowców Roślin Ogrodniczych "Hodowla Roślin o Podwyższonej Jakości. Kraków, 15-16 lutego 1996, 22-51 [in Polish].
10. Mejza I., 1997. Regresja. [w:] R. Kala. 13 sesji z Minitabem [Regression. [in:] R. Kala. 13 Sessions with Minitab]. Wyd. AR im. Augusta Cieszkowskiego, Poznań, 63-67 [in Polish].
11. Michalik B., 1993. Hodowla buraka ćwikłowego i szpinaku. Burak ćwikłowy [w:] K. Niemirowicz-Szczytt. Hodowla roślin warzywnych [Breeding of red garden beet and spinach. Red garden beet [in:] K. Niemirowicz-Szczytt. Vegetable Breeding]. Wydawnictwo SGGW, Warszawa, 315-328 [in Polish].
12. Polska Norma PN-72/A-77603. Przetwory warzywne. Warzywa suszone. 1972 [Polish Standard PN-72/A-77603. Vegetable Products. Dried Vegetables]. Polski Komitet Normalizacji, Warszawa [in Polish].
13. Polska Norma PN-72/R-75360. Warzywa świeże. Burak ćwikłowy. 1972. [Polish Standard PN-72/R-75360. Fresh Vegetables. Red Garden Beet]. Polski Komitet Normalizacji i Miar, Warszawa [in Polish].
14. Riggs T. J., 1989. The contribution of plant breeding to quality in vegetables. Acta Horticulturae 244, 87-98.
15. Saliba-Colombani V., Causse M., Philouze J., Buret M., Issanchou S., Lesschaeve I., 1999. QRLs for organoleptic quality in fresh market tomato. [in:] Scarascia Mugnozza G. T., Porceddu E., Pagnota M. A. (Eds.). Genetics and Breeding for Crop Quality and Resistance. Kluwer Academic Publisher, Netherlands, 291-299.
16. Żuradzka E., Antos M., Pawłowska B., 1996. Nowe odmiany warzyw z KHNO "POLAN" przydatne dla przetwórstwa [New vegetable cultivars from KHNO "POLAN" suitable for processing]. VI Ogólnopolski Zjazd Hodowców Roślin Ogrodniczych "Hodowla Roślin o Podwyższonej Jakości". Kraków, 15-16 lutego 1996, 160-164 [in Polish].

Urszula Braun-Młodecka
Department of Seed Science, Technology and Nursery Production
August Cieszkowski Agricultural University of Poznań,
Baranowo, ul. Szamotulska 28, 62-081 Przeźmierowo, Poland
tel. (+48 61) 814 21 87
e-mail: ula@serwisnasienny.pl

Responses to this article, comments are invited and should be submitted within three months of the publication of the article. If accepted for publication, they will be published in the chapter headed 'Discussions' in each series and hyperlinked to the article.