

# The influence of herbicides and their mixtures on total proteins content and on proper proteins in potato tubers

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## ABSTRACT

Field experiments were carried out at the Agricultural Experimental Nuisance Station of University of Podlasie in Siedlce in the years 1999–2001. The influence of herbicides and their mixtures on total proteins content and on proper proteins in eatable potato tubers were analysed. The weeding chemical agents (pesticides) used in the potato treatment increased the total protein content by 0.09–0.18% and proper proteins content by 0.15–0.34% in the tubers in contrast with the ones of the control object. The statistical analysis also revealed the importance of the cultivar and weather conditions during the experimental years.

**Keywords:** potato; herbicides; total proteins; proper proteins

The chemical composition of potato tubers is a variable characteristic (Keller and Baumgartner 1982, Roztropowicz 1989, Mazurczyk 1994), but weather conditions during the experiments (vegetation) modify the content of particular components (Ceglarek and Księżak 1992, Zrůst and Holá 1994, Mazurczyk and Lis 2001) as well as agro technical factors (Leszczyński and Lisińska 1985, Zarzecka and Gąsiorowska 2000, Klikocka 2001).

One of the basic components of the tuber apart from the starch is protein that exists in a quantity of 1.7 to 2.3% in the fresh weight, where as proper proteins from 35 to 68% (Roztropowicz 1989). The protein of potato tuber contains all exogenous amino acids in appropriate quantity, rich in lysine and, as one the not so numerous vegetable proteins, contains a biological value comparable to the animal one (Leszczyński 2002). According to Mazurczyk (1994), the content of total and protein nitrogen in tubers depends on less stabile characteristics, tightly connected with climate conditions during the vegetation. When it comes to the influence of herbicides on the quality of the crop, their opinion diverges. That's why, the aim of the experiments was to define the influence of some herbicides and their mixtures on total and proper proteins content in 3 cultivars of potato tubers.

## MATERIAL AND METHODS

The analysis was done from the results of sampling tubers from field experiments carried out at

the Agricultural Experimental Station of University of Podlasie in Siedlce in the years 1999–2001. The experiment was carried by the random sub block method in 3 replications on a light and strong argillaceous sand soil. The experiment was carried out on the base of 2 factors:

### I. Weed control methods

- 1 – control object – mechanical treatment until and after potato culture rising
- 2 – Sencor 70 WG 0.5 kg/ha
- 3 – Sencor 70 WG 0.5 kg/ha + Fusilade Super 1.5 l/ha (mixture)
- 4 – Sencor 70 WG 0.5 kg/ha + Fusilade Super 1.5 l/ha + adjuvant Olbras 88 EC 1.5 l/ha (mixture)
- 5 – Basagran 600 SL 2.5 l/ha
- 6 – Basagran 600 SL 2.5 l/ha + Focus Ultra 1.5 l/ha (mixture)
- 7 – Basagran 600 SL 2.5 l/ha + Focus Ultra 1.5 l/ha + adjuvant Olbras 88 EC 1.5 l/ha (mixture)

### II. Cultivars of potato: Ania, Baszta, Rywal

The mechanical treatment was applied on the referential experimental cultures 2 to 7 until the plant rising, where as herbicides and their mixtures were applied after the plant rising. Each year, organic fertilization has been used with manure (25 t/ha) and mineral one in the following quantities: 100 kg N, 100 kg P<sub>2</sub>O<sub>5</sub> and 150 kg K<sub>2</sub>O per 1 ha.

Table 1. Characteristic of weather conditions of the period of potato vegetation in 1999–2001 (Zawady Meteorological Station)

Years	Months						April–September
	April	May	June	July	August	September	
<b>Rainfalls (mm)</b>							sum
1999	87.3	26.4	121.7	21.9	77.4	27.8	362.5
2000	47.5	24.6	17.0	155.9	43.6	61.1	349.7
2001	69.8	28.0	36.0	55.4	24.0	108.0	321.2
Multiyear average (1981–1995)	52.3	50.0	68.2	45.7	66.8	60.7	343.7
<b>Air temperature (°C)</b>							average
1999	9.9	12.9	20.5	21.8	18.7	16.1	16.7
2000	12.9	16.5	29.6	19.0	19.1	11.8	16.5
2001	8.7	15.5	17.1	23.8	20.6	12.1	16.3
Multiyear average (1981–1995)	7.7	10.0	16.1	19.3	18.0	13.0	14.0
<b>Sielianinow's hydrothermic coefficients*</b>							average
1999	2.9	0.7	2.0	0.3	1.3	0.6	1.2 moist
2000	1.2	0.5	0.3	2.6	0.7	1.7	1.2 moist
2001	1.0	0.6	0.7	0.8	0.4	3.0	1.0 mild drought

\*below 0.5 drought, 0.6–1.0 mild drought, 1.1–2.0 moist, above 2.0 wet

The features of weather conditions in the years 1999–2001 are presented on the Table 1. Chemical analyses were done on dry material in 3 replications. The total and proper protein content was calculated from the total and protein nitrogen content using the coefficient 6.25. The total and protein nitrogen were fixed with Kjeldahl method on the 2300 Kjeltex Analyser Unit. The results of the analyses were done statistically with the help of the variance analysis and, the significance of the difference was tested with Tukey at the significance level  $P = 0.05$ .

## RESULTS AND DISCUSSION

The total protein content in tubers varied from 9.54 to 10.19% and was tightly dependent on weed control applied, on cultivars and weather conditions during the experiment years (Tables 2 and 3). Herbicides and their mixtures caused the growth of total protein content comparing with the tubers of the control object. They significantly increase the concentration of the given component after the use of the following herbicides: Sencor 70 WG, Sencor 70 WG + Fusilade Super, Sencor 70 WG + Fusilade Super + adjuvant Olbras 88 EC, Basagran 600 SL + Focus Ultra. The growth of

the protein content in tubers from fields sprayed with herbicides was also noticed by Mężykowska and Mazurczyk (1979), Ceglarek and Książak (1992), Woda-Leśniewska (1994), Zarzecka and Gąsiorowska (2000), Leszczyński (2002). On the other hand, Klikocka (2001) claimed that the chemical and mechanical-chemical treatments decreased the nitrogen level in potato tubers.

Among the cultivars grown, Rywal showed the highest content of total protein, Ania less where as Baszta the least. Once more, each cultivar reacted by increasing the protein content after chemical interventions. The significance of the influence of cultivars on the given characteristic was proved by numerous researches (Roztropowicz 1989, Mazurczyk 1994, Mitrus et al. 2003).

Weather conditions during the experimental years significantly differentiated the total protein content. The tubers of the mild drought year 2001 gathered the highest content of the given component but a lot less during the humid seasons of vegetation (1999 and 2000). The influence of weather conditions on protein content was proven in many scientific works (Mężykowska and Mazurczyk 1979, Zrůst and Holá 1994, Zarzecka and Gąsiorowska 2000, Mazurczyk and Lis 2001). Klikocka (2001) claimed that during the dry year, nitrogen was more (a relative result) than in the cold year for

Table 2. Content of total proteins in dry matter of potato tubers in %

Weed control methods	Years			Cultivars			Average
	1999	2000	2001	Ania	Baszta	Rywal	
1. Control object – mechanical weeding	9.61	9.74	9.75	9.62	9.55	9.93	9.70
2. Sencor 70 WG	9.66	9.82	9.88	9.70	9.65	10.01	9.79
3. Sencor 70 WG + Fusilade Super (mixture)	9.73	9.86	10.08	9.82	9.77	10.08	9.89
4. Sencor 70 WG + Fusilade Super + adjuvant Olbras 88 EC (mixture)	9.63	9.81	9.91	9.69	9.64	10.02	9.78
5. Basagran 600 SL	9.66	9.78	9.88	9.71	9.63	9.98	9.77
6. Basagran 600 SL + Focus Ultra (mixture)	9.69	9.83	10.01	9.78	9.69	10.06	9.84
7. Basagran 600 SL + Focus Ultra + adjuvant Olbras 88 EC (mixture)	9.63	9.79	9.87	9.69	9.62	9.97	9.76
Average	9.66	9.81	9.91	9.72	9.65	10.00	9.79
Average for objects 2–7	9.67	9.82	9.94	9.73	9.67	10.02	9.81

$LSD_{0.05}$  between weed control methods = 0.08, cultivars = 0.14, years = 0.10

Interaction: weed control methods × cultivars = 0.14, weed control methods × years = 0.11

about 5%. On the other hand, Kłosińska-Rycerska (1973) showed that, after the use of herbicides, in dependence on the humidity of the year, the protein content grows up to 24% (relative result). The experiments carried out revealed that there is an interaction between weed control methods and the years, as well as between of weed control methods and the cultivars. It means that herbicides differently influence cultivars and experimental years differently in weather conditions.

The chemical analysis of tubers revealed that the proper protein content in potato tubers tightly depended on the weed control methods, cultivars and weather conditions during the experimental years (Tables 4 and 5). Herbicides and their mixtures are responsible for the growth of proper protein content, comparing with the one of tubers gathered from the control object. Kołpak et al. (1987), as well as Sawicka and Kuś (2002) observed similar changes.

Table 3. Content of total protein in % of dry tuber matter depending on cultivar

Years	Cultivars			Average
	Ania	Baszta	Rywal	
1999	9.59	9.54	9.84	9.66
2000	9.76	9.67	9.99	9.81
2001	9.80	9.74	10.19	9.91
Average	9.72	9.65	10.00	9.79

$LSD_{0.05}$  between years = 0.10, cultivars = 0.14

Interaction: years × cultivars = n.s.

n.s. = not significant

Table 4. Content of proper proteins in dry matter of potato tubers in %

Weed control methods	Years			Cultivars			Average
	1999	2000	2001	Ania	Baszta	Rywal	
1. Control object – mechanical weeding	4.51	4.69	4.85	4.62	4.23	5.21	4.68
2. Sencor 70 WG	4.57	4.78	5.12	4.77	4.43	5.26	4.82
3. Sencor 70 WG + Fusilade Super (mixture)	4.74	4.95	5.37	4.90	4.68	5.49	5.02
4. Sencor 70 WG + Fusilade Super + adjuvant Olbras 88 EC (mixture)	4.81	5.00	5.26	4.72	4.80	5.55	5.02
5. Basagran 600 SL	4.60	4.83	5.18	4.76	4.57	5.28	4.87
6. Basagran 600 SL + Focus Ultra (mixture)	4.82	4.91	5.30	4.83	4.78	5.42	5.01
7. Basagran 600 SL + Focus Ultra + adjuvant Olbras 88 EC (mixture)	4.66	4.78	5.06	4.73	4.45	5.32	4.83
Average	4.68	4.85	5.16	4.76	4.56	5.36	4.89
Average for objects 2–7	4.70	4.88	5.22	4.79	4.62	5.39	4.93

$LSD_{0.05}$  between weed control methods = 0.04, cultivars = 0.03, years = 0.03

Interaction: weed control methods × cultivars = 0.08, weed control methods × years = 0.07

Rywal contained the highest quantity of proper protein – 5.39% in average, Baszta less – 4.62% in average. Once more, the interaction between the weed control methods and cultivars was proven, what means that herbicides used and the different reactions on the cultivars. The highest increase in proper protein concentration in tubers was observed with Baszta. The influence of cultivars on the given content was proved by Roztropowicz (1989), Zarzecka and Gąsiorowska (2000). On the contrary, Mazurczyk (1994) did not show

the influence of cultivars on protein content in tubers. The years, in which the experiments were carried out, differentiate the given characteristic. In the mild drought year 2001, tubers gathered the highest rate of proteins. The growth in the proper protein content during the drought was also observed by Davies et al. (1989), Zrůst and Holá (1994), Mazurczyk and Lis (2001).

The growth of the proper protein in the total protein was proven under the influence of herbicides used and their mixtures, this is what is also

Table 5. Content of proper proteins in % of dry tuber matter depending on cultivar

Years	Cultivars			Average
	Ania	Baszta	Rywal	
1999	4.56	4.21	5.26	4.68
2000	4.57	4.59	5.38	4.85
2001	5.15	4.89	5.45	5.16
Average	4.76	4.56	5.36	4.89

$LSD_{0.05}$  between years = 0.03, cultivars = 0.03

Interaction: years × cultivars = 0.04

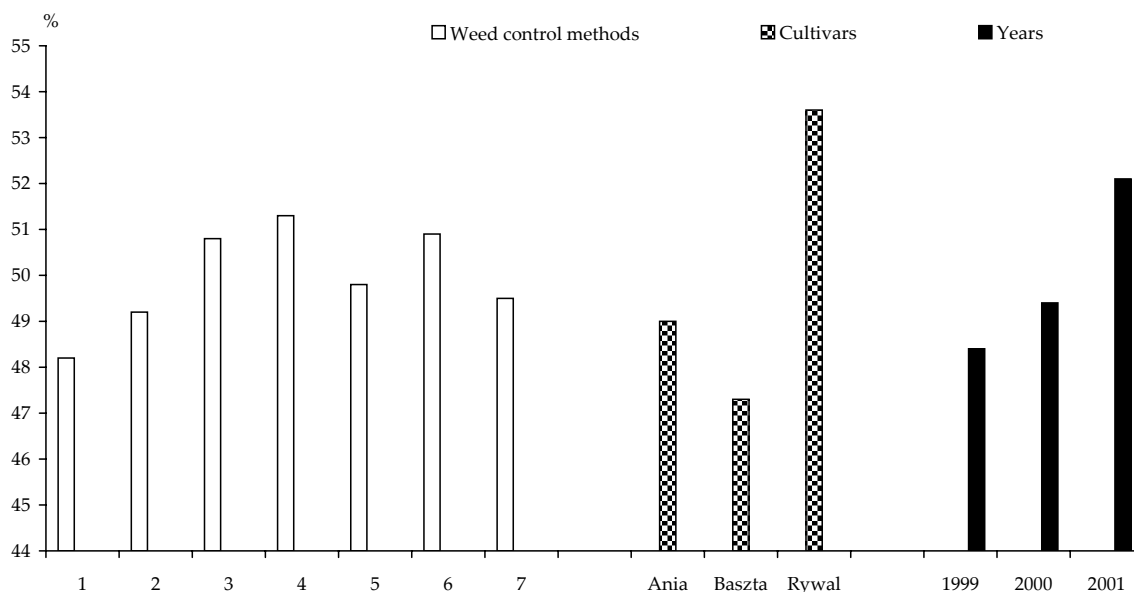


Figure 1. Percentage of the proper proteins in the total proteins depending on weed control methods, cultivars and years

claimed by Kołpak et al. (1987), Sawicka and Kuś (2002) (Figure 1). On the other hand, Leszczyński and Lisińska (1985) observed a decrease of proper protein in the total protein in potato tubers.

In the mild drought year 2001, there was an increase of proper protein in the total protein in comparison with the humid years. Kołpak et al. (1987) also confirm that.

In the experiments of Wyszowski and Cieccko (2001), other preparations – protective fungicides caused the decrease in the proper and total protein content in potato tubers.

Numerous authors such as (Kłosińska-Rycerska 1973, Leszczyński 2002) demonstrate that the changes in chemical components of potato tubers caused by the use of herbicides and their mixtures are not generally significant, whereas the site, the method of culture or the cultivars have a greater influence than herbicides.

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## ABSTRAKT

### Vliv herbicidů a jejich směsí na obsah celkových bílkovin a čistých bílkovin v hlízách brambor

V letech 1999–2001 byly provedeny polní pokusy na zemědělské pokusné stanici Podlaské Univerzity v Siedlcích. Byl sledován vliv herbicidů a jejich směsí na obsah celkových bílkovin a čistých bílkovin v hlízách konzumních brambor. Použití herbicidů zvýšilo obsah celkových bílkovin v hlízách o 0,09–0,18 % a čistých bílkovin o 0,15–0,34 % v porovnání s jejich obsahem u kontrolní varianty. Statistická analýza také odhalila průkazný vliv odrůdy a povětrnostních podmínek pokusných let na obsah bílkovin.

**Klíčová slova:** brambory; herbicidy; celkové bílkoviny; čisté bílkoviny

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