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# INFLUENCE OF HERBICIDE AND ADJUVANT APPLICATION ON RESIDUES IN SOIL AND PLANT OF SUGAR BEET

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**Abstract:** The aim of investigations was to understand the effect of herbicides application on soil environment and residues in sugar beet. Field experiments were carried out during 1997–2001 on arable field near Wrocław. Herbicides to weed control in sugar beet were applied at recommended dose alone and in mixture with adjuvants.
Samples of soil, leaves and roots of sugar beet were taken on the day of harvest. Additional, soil samples were taken six weeks (in autumn 2000) and five months (in spring 2001) after harvest. All samples were analysed (herbicide residues) using the high-performance liquid chromatography (HPLC) with UV-detection and gas liquid chromatography (GLC) with ECD.
Residues of active ingredient of herbicides determined in roots and leaves of sugar beet did not exceed acceptable values included in EU standards and herbicides use in normal agricultural practice should not present problems for following crops.
Moreover, the addition of adjuvants caused an increase of the herbicide active ingredient residue in soil, leaves and roots of sugar beet samples in comparison with the treatments, where herbicides alone were used.

**Key words:** herbicide, adjuvant, sugar beet, residue, HPLC

## INTRODUCTION

Information on the residue and degradation rate of the herbicide active ingredient allows to evaluation behavior of herbicide in environment. The application of low levels of herbicide does not guarantee high levels of environmental tolerance. In some cases, it has been demonstrated that sensitive plants were damaged by dosages lower than 1% of the initial application rate (Bayer et al. 1987). These low soil and plant residues constitute problems for their determination and make it difficult to estimate the effect of these herbicides on rotational crops and health of consumers (Menne et al. 2001).

Herbicides are often applied at rates higher than that required for weed control under ideal conditions. This is done primarily to counteract losses that occur from the site of action in the plant zone (McMullan et al. 1998). In soil the biological activity of herbicides may be decreased by chemical or biological degradation of active ingredients. Adsorption by soil colloids, absorption by plants or leaching to lower layers of the soil profile influences also the biological activity of herbicides in soil (Edwards 1973; Harris 1969).

Monitoring of herbicidal residues allows quality control of soil and agricultural products. The results from monitoring researches are comparable with acceptable amounts showed in standards. Polish laboratories have been used the EU standards for several years. The standards define maximum residue limits for different active ingredients and plant products.

The aim of investigations was to understand the effect of herbicides and adjuvant application on residues in soil and plant of sugar beet.

## MATERIALS AND METHODS

Field experiments were carried out during five-year-period (1997–2001) on arable field near Wrocław. The field trial was laid out as a randomized complete block design with three replicates. All farming activities were carried out in accordance with conventional agricultural practice and in line with recommendations from officials. Herbicides to weed control in sugar beet were applied at recommended dose alone and in mixture with adjuvants (Atpolan® 80 EC, Agromix Poland; Olbras® 88 EC, Obrol Poland; Olejan® 85 EC, Danmar Poland – see table 1). The following active substances of herbicide were applied: phenmedipham, desmedipham, ethofumesate (Betanal Progress® AM 180 EC, Aventis Crop Science), metamitron (Goltix® 70 WP, Bayer), chloridazone (Expander® 400 SC, BASF), quizalofop (Targa Super® 05 EC, Nissan Chemical) and fluazifop (Fusilade Super® 125 EC, Syngenta). The rates of active ingredient of herbicides applied in experiments are given in table 2.

Table 1. Characteristics of adjuvants used in experiments

| Common name of adjuvant | Active substances | Dose [l*ha$^{-1}$] |
|---|---|---|
| Atpolan 80 EC | paraffin oil emulsifier | 1.5 |
| Olbras 88 EC | post-refined fatty acids emulsifier | 1.5 |
| Olejan 85 EC | rape oil emulsifier | 1.5 |

Table 2. The rate of herbicides' active ingredients applied in experiments

| Active ingredient (a.i.) of herbicide | Dose [g a.i.*ha$^{-1}$] |
|---|---|
| phenmedipham | 360 |
| desmedipham | 360 |
| ethofumesate | 360 |
| chloridazon | 2700 |
| metamitron | 3500 |
| quizalofop-P-ethyl | 125 |
| fluazifop-P-buthyl | 312 |

Samples of soil, leaves and roots of sugar beet were taken on the day of harvest. Samples were taken from the middle of each plot, to avoid interference and side effects from the neighboring plots. The soil samples were taken at a soil depth of 0–20 cm. Additional, soil samples were taken six weeks (in autumn 2000) and five months (in spring 2001) after harvest.

Samples from each plot were well mixed and stored in polyethylene bags at –18°C until sample extraction. Soil moisture content was determined for each soil sample after heating subsamples to dryness at 105°C for 24 h.

Determination of residues consists of three elementary processes: extraction of active ingredients from samples, chemical cleaning of extract (and esterification if needed) and quantitative determination. All samples were analysed (herbicide residues) using the high-performance liquid chromatography (HPLC) with UV-detection and gas liquid chromatography (GLC) with ECD (Electron Capture Detector) detection.

Results of residue data from field trials were calculated using the statistical program Statgraphics Plus for Windows, version 1.41 PL.

## RESULTS AND DISCUSSION

At the harvest time, about 70%–85% of soil, leaves and roots of sugar beet samples contained detectable residues all of herbicide active ingredients. The level of residues was dependent on the kind and dosage of herbicide, addition of adjuvant and weather condition in individual vegetation seasons.

### Residues in soil

The maximum residues detected in soil samples collected for six years amount to:

- for recommended dose of herbicides applied alone:
  0.041 $mg*kg^{-1}$ of phenmedipham, 0.039 $mg*kg^{-1}$ of desmedipham, 0.062 $mg*kg^{-1}$ of ethofumesate, 0.102 $mg*kg^{-1}$ of chloridazone, 0.118 $mg*kg^{-1}$ of metamitron, 0.014 $mg*kg^{-1}$ of quizalofop and 0.019 $mg*kg^{-1}$ of fluazifop;
- for recommended dose of herbicides applied with addition of adjuvants:
  0.047 $mg*kg^{-1}$ of phenmedipham, 0.044 $mg*kg^{-1}$ of desmedipham, 0.069 $mg*kg^{-1}$ of ethofumesate, 0.120 $mg*kg^{-1}$ of chloridazone, 0.124 $mg*kg^{-1}$ of metamitron, 0.016 $mg*kg^{-1}$ of quizalofop and 0.022 $mg*kg^{-1}$ of fluazifop.

### Residues in sugar beet leaves

The maximum residues determined in leaves of sugar beet samples amount to:

- for recommended dose of herbicides applied alone:
  0.056 $mg*kg^{-1}$ of phenmedipham, 0.039 $mg*kg^{-1}$ of desmedipham, 0.058 $mg*kg^{-1}$ of ethofumesate, 0.158 $mg*kg^{-1}$ of chloridazone, 0.098 $mg*kg^{-1}$ of metamitron, 0.010 $mg*kg^{-1}$ of quizalofop and 0.015 $mg*kg^{-1}$ of fluazifop;
- for recommended dose of herbicides applied with addition of adjuvants:
  0.064 $mg*kg^{-1}$ of phenmedipham, 0.043 $mg*kg^{-1}$ of desmedipham, 0.058 $mg*kg^{-1}$ of ethofumesate, 0.164 $mg*kg^{-1}$ of chloridazone, 0.106 $mg*kg^{-1}$ of metamitron, 0.012 $mg*kg^{-1}$ of quizalofop and 0.014 $mg*kg^{-1}$ of fluazifop.

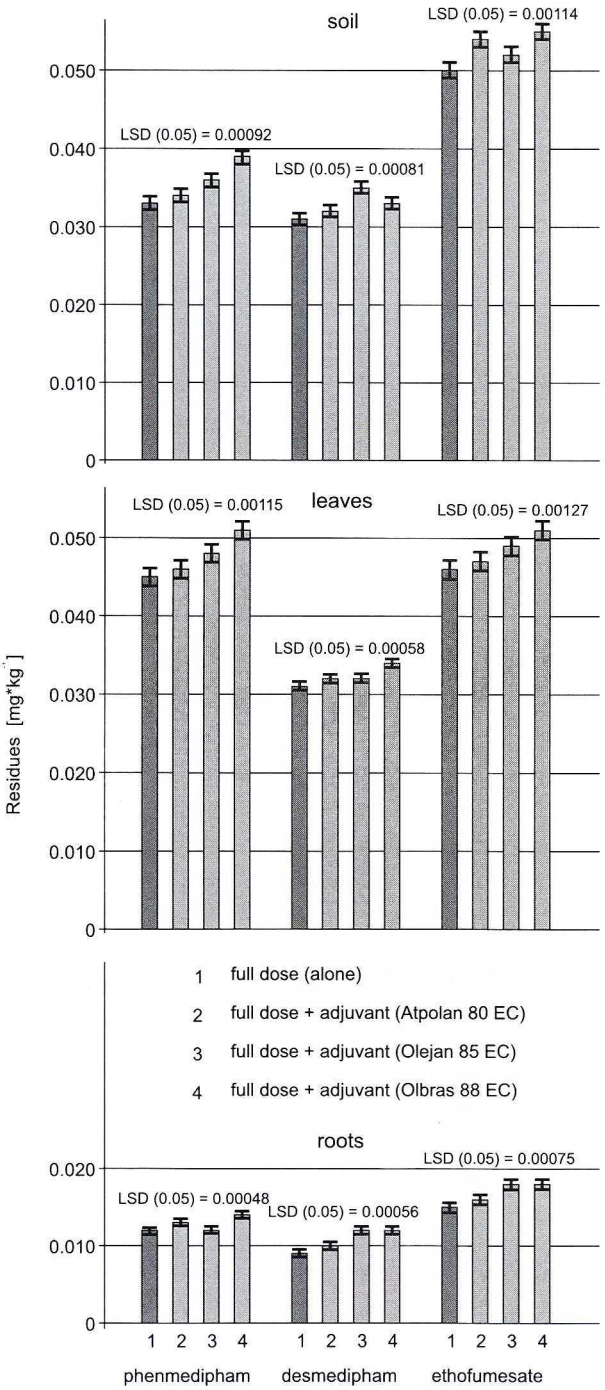


Fig. 1. Residues of phenmedipham, desmedipham and ethofumesate in soil, leaves and roots of sugar beet (Biestrzyków 2000)

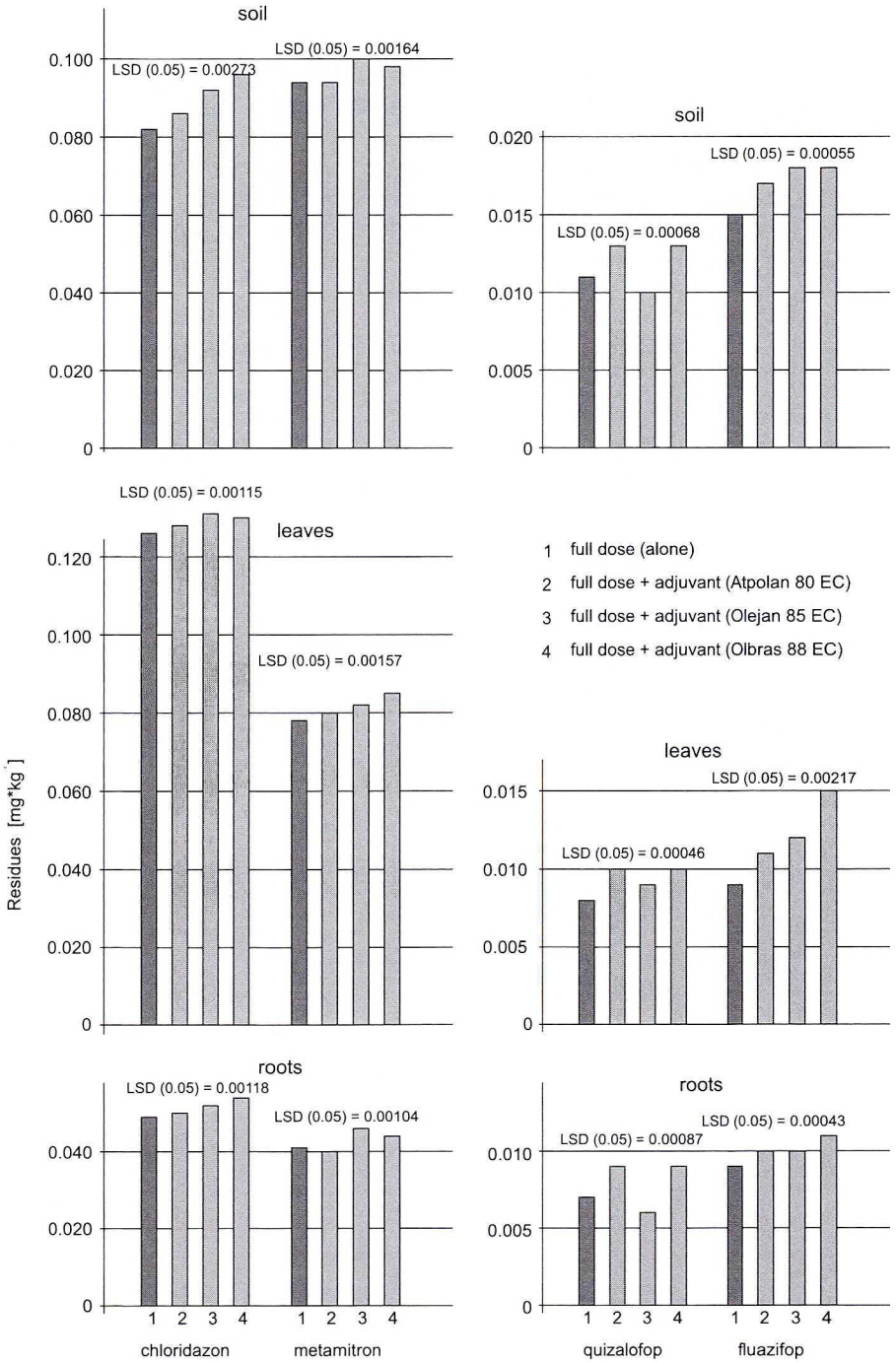


Fig. 2. Residues of chloridazon, metamitron, quizalofop and fluazifop in soil, leaves and roots of sugar beet (Biestrzyków 2000)

## Residues in sugar beet roots

The maximum residues determined in roots of sugar beet samples amount to:

- for recommended dose of herbicides applied alone:
  0.016 mg*kg$^{-1}$ of phenmedipham, 0.012 mg*kg$^{-1}$ of desmedipham, 0.019 mg*kg$^{-1}$ of ethofumesate, 0.062 mg*kg$^{-1}$ of chloridazone, 0.052 mg*kg$^{-1}$ of metamitron, 0.009 mg*kg$^{-1}$ of quizalofop and 0.012 mg*kg$^{-1}$ of fluazifop;
- for recommended dose of herbicides applied with addition of adjuvants:
  0.018 mg*kg$^{-1}$ of phenmedipham, 0.015 mg*kg$^{-1}$ of desmedipham, 0.022 mg*kg$^{-1}$ of ethofumesate, 0.068 mg*kg$^{-1}$ of chloridazone, 0.058 mg*kg$^{-1}$ of metamitron, 0.011 mg*kg$^{-1}$ of quizalofop and 0.014 mg*kg$^{-1}$ of fluazifop.

Figures 1 and 2 show exemplary results from field experiment conducted in 2000 year on sugar beet plantation located in Biestrzyków (near Wrocław).

The residues of active ingredient of herbicides determined in roots and leaves of sugar beet did not exceed acceptable amounts showed in EU standards (Tab. 3).

Monitoring of residues in soil and plant materials is conducted for different crops and herbicides. Dąbrowski et al. (1996; 2001) demonstrated similar results for other crops, where determined residues concentration was lower than acceptable values showed in standards.

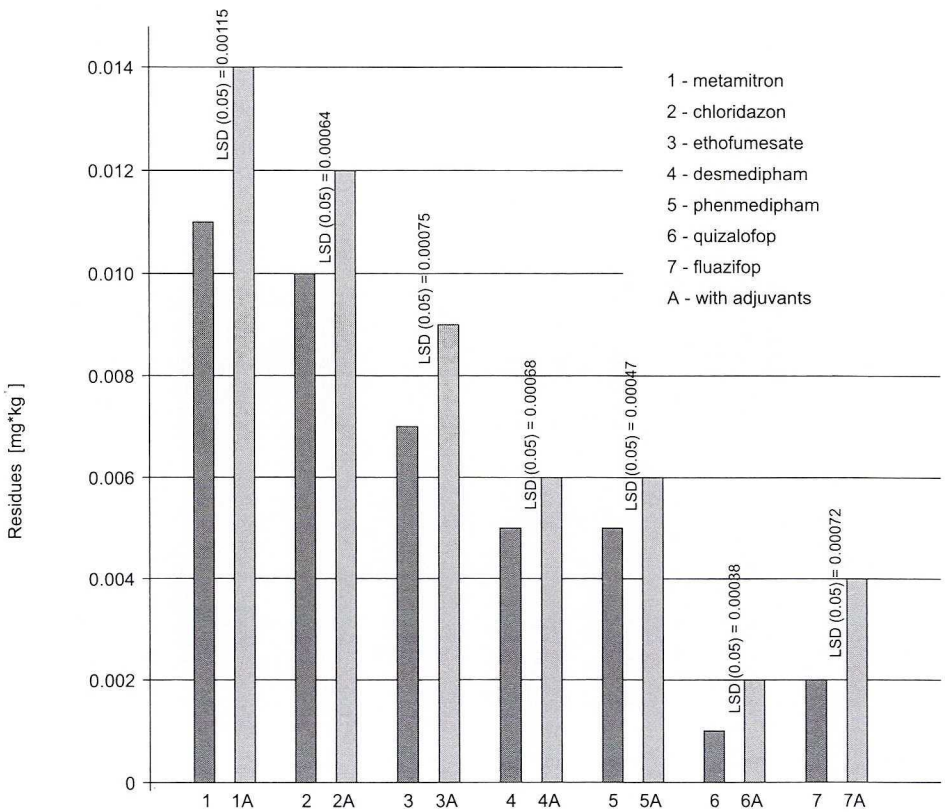


Fig. 3. Residues in soil 6 weeks after sugar beet harvest (Biestrzyków 2000)

Table 3. Maximum residue of herbicides active ingredient detected in experiments (1997–2001) and EU standards (Różański 1996)

| Active ingredient of herbicide | Admissible level of residues (EU standards) [mg*kg$^{-1}$] | Maximum residues detected in experiment [mg*kg$^{-1}$] | |
|---|---|---|---|
| | Sugar beet | Roots of beet | Leaves of beet |
| phenmedipham | 0.1 | 0.018 | 0.064 |
| desmedipham | 0.1 | 0.015 | 0.044 |
| ethofumesate | 0.1 | 0.022 | 0.043 |
| chloridazon | 0.5 | 0.068 | 0.164 |
| metamitron | 0.2 | 0.058 | 0.106 |
| quizalofop-P | 0.1 | 0.011 | 0.012 |
| fluazifop-P | 0.1 | 0.014 | 0.018 |

The results of the residue analyses in the soil samples taken additionally demonstrated that low residue concentrations six weeks after sugar beet harvest (Fig. 3) and lack of detectable residues in soil in spring (5 months after harvest) should not cause any problems for following crops.

The addition of adjuvants caused an increase of the herbicide active ingredient residue in soil, leaves and roots of sugar beet samples in comparison with the objects, where herbicides were used only. Other authors obtained similar results with adjuvants and trifluralin (Swarcewicz 1996; Swarcewicz et al. 1998), atrazine (Swarcewicz and Muliński 1996) and phenmedipham (Kucharski 1998; Sumisławska and Kostowska 1991).

## CONCLUSION

Researches and monitoring of herbicidal residues allowed quality control of soil and plant products. Residues of active ingredient of herbicides determined in roots and leaves of sugar beet did not exceed acceptable values included in EU standards and herbicides use in normal agricultural practice should not present problems for following crops.

Moreover, the addition of adjuvants caused an increase of the herbicide active ingredient residue in soil, leaves and roots of sugar beet samples in comparison with the treatments, where herbicides alone were used.

## REFERENCES

Bayer E.M., Brown H.H., Duffy M.J. 1987. Sulfonylurea herbicide soil relations. The BCPC Conferences – Weeds 2: 531–540.

Dąbrowski J., Gąsior J., Janda T., Krause A., Morzycka B., Murawska M., Sadło S., Barylska E., Gierschendorf Z., Giza I., Langowska B., Martinek B., Michel M., Rupar J. 1996. Obraz skażeń pozostałościami pestycydów upraw rolnych i gleb w Polsce w latach 1991–1995. Prog. Plant Protection/Post. Ochr. Roślin 36 (1): 379–390.

Dąbrowski J., Nowacka A., Martinek B., Walorczyk S., Drożdżyński D., Schwarz K., Kudła M., Gierschendorf Z., Chmielewska E., Barylska E., Ziółkowski A., Giza I., Murawska M., Sztwiertnia U., Morzycka B., Sadło S., Rupar J., Langowska B., Michel M. 2001. Obraz skażeń pozostałościami chemicznych środków ochrony roślin upraw rolniczych w Polsce w latach 1996–2000. Prog. Plant Protection/Post. Ochr. Roślin 41 (1): 95–109.

Edwards C.A. 1973. Biological activity of herbicides. p. 63–107. In "Environmental Pollution by Pesticides" (C.A. Edwards, ed.). Plenum Press, New York, 409 pp.

Harris C.I. 1969. Leaching of triazine herbicides to lower layers of the soil profile. J. Agric. Food Chem., 17: 71–80.

Kucharski M. 1998. Wpływ herbicydów stosowanych łącznie z adiuwantami na poziom ich pozostałości w buraku cukrowym. Prog. Plant Protection/Post. Ochr. Roślin 38 (2): 602–605.

McMullan P.M., Thomas J.M., Volgas G. 1998. HM9679 – A spray adjuvant for soil-applied herbicides. Proc. 5th International Symposium on Adjuvants for Agrochemicals. Memphis, USA: 285–290.

Menne H.J., Berger B.M. 2001. Influence of straw management, nitrogen fertilization and dosage rates on the dissipation of five sulfonylureas in soil. Weed Res., 41 (3): 229–244.

Różański L. 1996. Vademecum pestycydów. Wyd. Agra-Enviro Lab., Poznań, 276 pp.

Sumisławska J., Kostowska B. 1991. Wpływ wspomagaczy (adiuwantów) na pozostałości fenmedifamu. Materiały 31. Sesji Nauk. Inst. Ochr. Roślin, cz. 2: 152–156.

Swarcewicz M. 1996. Wpływ adiuwantów olejowych na trwałość trifluraliny w glebie lekkiej. Zesz. Nauk. AR Szczecin 173, Rolnictwo 63: 211–217.

Swarcewicz M., Muliński Z. 1996. Effect of spray adjuvants Atpol and Olbras on atrazine fate in soil and water. Proc. 2nd International Weed Control Congress. Copenhagen, Denmark: 343–348.

Swarcewicz M., Muliński Z., Zbieć I. 1998. Influence of spray adjuvants on the behavior of trifluralin in the soil. Bull. Environ. Contam. Toxicol., 60: 569–576.

## POLISH SUMMARY

### WPŁYW STOSOWANIA HERBICYDÓW I ADIUWANTÓW NA POZIOM ICH POZOSTAŁOŚCI W GLEBIE I BURAKACH CUKROWYCH

Celem prowadzonych badań była ocean wpływu stosowania herbicydów na poziom pozostałości substancji aktywnych tych herbicydów w glebie, liściach i korzeniach buraka cukrowego. Badania prowadzono na polach produkcyjnych w latach 1997–2000, zlokalizowanych w okolicy Wrocławia. Herbicydy stosowane do odchwaszczania plantacji buraka cukrowego aplikowano w dawkach rekomendowanych samodzielnie oraz z dodatkiem adiuwantów (Atpolan 80 EC, Olbras 88 EC, Olejan 85 EC).

Próby gleby, liści i korzeni buraka cukrowego pobierano w dniu zbioru. Dodatkowo próby gleby z omawianych doświadczeń pobrano 6 tygodni po zbiorze (jesień 2000) oraz 5 miesięcy po zbiorze (wiosna 2001). Analizę pozostałości wykonano techniką chromatografii cieczowej (HPLC-UV) i chromatografii gazowej (GLC-ECD).

Monitoring zanieczyszczeń herbicydowych pozwala na jakościową kontrole gleby i produktów roślinnych. Wyniki badań nie wykazały, by w liściach i korzeniach buraka cukrowego wystąpiło nagromadzenie pozostałości substancji aktywnych oznaczanych herbicydów, w stężeniu przekraczającym wartości podane w normach. Przestrzeganie zaleceń producentów środków ochrony roślin, jak również zasad dobrej praktyki rolniczej znacząco ogranicza możliwości wystąpienia jakichkolwiek skażeń gleby, czy produktów roślinnych i nie stanowi zagrożenia dla upraw następczych. Ponadto, wyniki doświadczeń wskazują na możliwość wzrostu pozostałości substancji aktywnych herbicydów po zastosowaniu ich łącznie z adiuwantami.