

## The effect of foliar fertilization on yield and quality of American ginseng roots (*Panax quinquefolium* L.)

RAFAŁ MAGDZIAK, BARBARA KOŁODZIEJ\*

Department of Industrial and Medicinal Plants,  
Agricultural University,  
Akademicka 15, 20-950 Lublin, Poland  
corresponding author: phone: +48 81 4456679,  
e-mail: barbara.kolodziej@ar.lublin.pl

### S u m m a r y

In a four-year-lasting field experiment the effects of foliar fertilisation with Mikrosol U and Ekolist Standard (in concentration of 1.5%) on yield and quality of American ginseng (*Panax quinquefolium* L.) roots were studied. It was proved that both preparations had a slender influence on roots' length and diameter in the first year of vegetation. However, in the next three years of cultivation their positive effects on roots parameters were observed, resulting in significant yield increase. Raw material from plots sprayed with foliar fertilizers was characterized by better healthiness and higher active substances content. From two preparations concerned, Mikrosol U appeared to be more effective.

*Key words: foliar fertilization, American ginseng , Panax quinquefolium L.*

Herbal medicines made of ginseng roots are very popular. Similarly to other herb species, increasing demand for its raw material resulted in an introduction of ginseng into field cultivation. *Panax quinquefolium* L. commonly called American ginseng is a slow growing, long-living plant native to the hardwood of Canada and the USA. Its roots have been harvested from natural state and cultivated in Ontario, Canada and Wisconsin, USA for over 100 years. Nowadays its cultivation has expanded from North America to Asia, Australia and Europe (China, Australia, Holland, France and Poland). American ginseng culture is a difficult task. The final result mainly depends on ability to create optimal conditions for plants growth and development [1, 2].

Foliar fertilisation has not been used in ginseng cultivation so far, although its positive influence on the other medicinal plants species suggests that its appli-

cation could increase yields and quality of American ginseng raw material [3, 4]. Thus, the aim of this study was to determine the effect of two commercially available foliar fertilizers: Mikrosol U or Ekolist Standard application on *Panax quinquefolium* yield and quality.

## MATERIALS AND METHODS

An experiment lasting four years (1999–2003) was carried out on experimental fields of Agricultural University in Lublin, located on sandy soil with the pH 5.4, medium phosphorous (66 mg kg<sup>-1</sup> of soil), potassium (74 mg kg<sup>-1</sup> of soil) and magnesium content (28 mg kg<sup>-1</sup> of soil). Stratified seeds of American ginseng were sown in autumn 1998 on raised beds (30–40 cm, 1.2 m wide) in distance of 15 x 5 cm on plots with 2.4 m<sup>2</sup> area in 5 replications with the soil mulched with oat straw afterwards. Winter rye, white mustard and then buckwheat dug out one by one as green fertilizers were ginseng's forecrops in a previous year. During vegetation plantation was shaded with plastic fabric designed for 85% reduction in light penetration, weeded and protected against fungal diseases [1]. Plots were fertilized with 43.6 kg P ha<sup>-1</sup>, 166 kg K ha<sup>-1</sup> (single application, before seeds sowing) and every spring before vegetation with 50 kg N ha<sup>-1</sup>. Every year Mikrosol U or Ekolist Standard were applied three times a year during intensive plants growth (June and July, in 10 days distance) in concentration of 1.5% (50 ml of solution per plot) compared to control plots (with tap water application).

Every autumn 10 randomly chosen plants from each plot were taken to determine fresh and air dry weight, length and diameter of roots as well as the number of lateral roots. In the autumn of 4<sup>th</sup> year all roots were harvested to determine number of roots per plot (including infected with fungal diseases) and, after drying in 38°C, yields of air dry weight of roots were obtained. After that chemical analysis (using HPLC method) of total ginsenosides content was done in the Department of Biology and Pharmaceutical Biotechnology at the Medical University in Łódź.

## RESULTS AND DISCUSSION

In the first year of vegetation experimental factors did not evidently affect the quality parameters of ginseng roots. In following cultivation years spraying with Mikrosol U and Ekolist positively influenced the total length of roots. Roots gathered from plots with foliar fertilization were significantly longer in comparison to the control ones (on average by 2.9 cm, 3.4 cm and 6.1 cm in three following years of vegetation, see Table 1). Similarly to earlier studies [4] foliar fertilization also caused a significant increase in ginseng roots diameter (Table 1).

Table 1.

The effect of foliar fertilization on American ginseng roots characteristic in following four years of vegetation.

	year of vegetation			
	I	II	III	IV
total length of root (cm)				
Ekolist	6.3	16.7	19.4	19.7
Mikrosol U	7.0	15.9	19.8	21.2
control	5.4	13.4	16.2	14.3
LSD (0.05)	-	1.91	1.89	1.94
diameter of root (cm)				
Ekolist	0.68	1.62	1.90	1.99
Mikrosol U	0.69	1.59	1.90	2.03
control	0.63	1.00	1.75	1.73
LSD (0.05)	0.06	0.46	0.15	0.18
number of lateral roots (unit)				
Ekolist		2.93	4.30	5.05
Mikrosol U		2.83	4.40	5.45
control		2.48	4.28	5.18
LSD (0.05)		-	-	-
air dry weight of single root (g)				
Ekolist	0.26	2.74	6.13	7.15
Mikrosol U	0.29	2.52	6.30	7.60
control	0.22	2.11	4.39	5.90
LSD (0.05)	0.07	0.58	0.76	1.07

Roots with a lot of lateral branches are considered as a raw material with better medical value. In the experiment the number of lateral roots increased along with plant age (on average from 1.2 in the first to 4.7–5.8 in the fourth year of cultivation, see Table 1). Statistical analysis did not confirm a positive relation between foliar fertilization and the number of lateral roots.

Every year roots evaluation made after the end of vegetation period showed a positive effect of foliar fertilisation application. In four following years of cultivation the highest air dry weight of roots was observed on the plots with Mikrosol U application. In general, air dry weight of single root from the plots sprayed with foliar fertilizers in comparison to the control ones was on an average 24% higher during first three years of ginseng vegetation and increased to 34% in the last year. It is worth emphasizing that significant effect of Ekolist application was observed only in the last year of vegetation (Table 1). Yield increase after Mikrosol U application was noted by Jabłoński [5-7], who obtained average 6.4% increase of potato yields, comparing to controls. Positive effects of foliar fertilization were also observed in vegetable production. Kołota and Osińska [3] proved that Ekolist application resulted in 20.3% increase in cabbage, 7.3% in cucumbers and 10.8% in onion yields. At the same time Berbec' et al. [8] showed that foliar fertilization with

Ekolist stimulated thyme growth, which resulted in the increase of herb yields (by 15-26%). In the case of American ginseng foliar fertilization with Tytoń-vit and Tytanit resulted in significant both above ground parts and roots yield increase [4].

The experiment showed a positive effect of foliar fertilization on yields of roots dug out in the 4<sup>th</sup> year of vegetation. The highest yield of air dry weight of roots (on average higher by 17.6% in comparison with the control plots) was obtained on plots with Mikrosol U application. Ekolist application also positively affected raw material yield (yields increment amounted to 12%). Statistical analysis showed also positive effect of foliar fertilization on root number per plot during harvesting. On the plots with Mikrosol U and Ekolist application mean number of roots per plot was significantly higher in comparison to control ones (effects of two preparations compared were almost the same, see Table 2).

**Table 2.**

The effect of foliar fertilization on yield of air dry matter of roots (g per plot), roots number (unit per plot) and percentage of roots with fungal diseases symptoms (%) in the fourth year of cultivation.

	Ekolist	Mikrosol U	control	LSD (0.05)
yield of air dry matter of roots(g plot-1)	173.6	174.1	152.6	17
number of roots (unit per plot)	61.4	61.9	49.6	3.27
percentage of roots infected with fungal diseases (%)	7.1	7.7	9.5	0.6

Root evaluation after 4 years of vegetation showed that foliar fertilization has a positive effect on its quality. Raw material obtained from the plots with Mikrosol U and Ekolist application is characterised by 2% smaller percentage of roots infected by fungal diseases in comparison to control ones (Table 2). The results agree with Biesiada and Kołota [9] as well as Kołota and Osińska [3] who observed that Ekolist application in a celery culture decreases septoriososis symptoms. Ginsenosides content is an important factor in ginseng raw material quality. Positive effect of foliar fertilisation on active substances content in roots was stated. In theory, ginsenosides yield, as a product of percentage content and yield of roots, was the highest in the object with Mikrosol U application (Figure 1). The same relation obtained Kołodziej [4] as well as Grzeškiewicz and Trawczyński [10].

## CONCLUSIONS

1. Foliar fertilization positively affected American ginseng root parameters (especially after Mikrosol U application) and, as a consequence, the yield of roots harvested after four-year-cultivation.
2. Mikrosol U and Ekolist application had both nutritional and protective effect on ginseng, which resulted in better raw material quality.
3. Significantly higher total ginsenoside content and yield were obtained from the plots sprayed with foliar fertilizers.

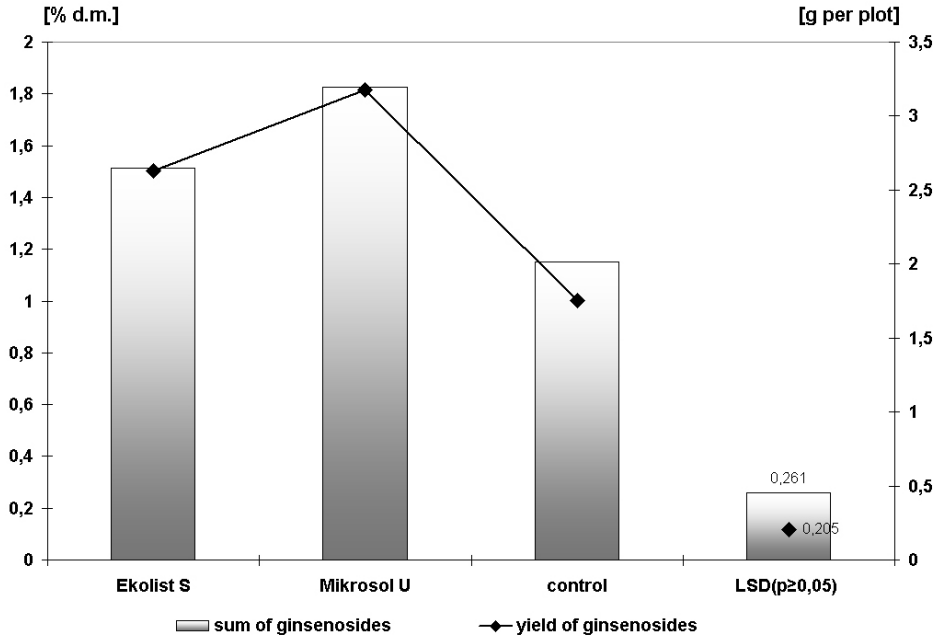


Fig. 1 The effect of foliar fertilization on the ginsenosides content (% d. m.) and yield (g·plot<sup>-1</sup>)

## REFERENCES

1. Anon. Ginseng production guide for commercial growers - 2003 ed. British Columbia Ministry of Agriculture, Food and Fisheries, Canada 2003;225 pp.
2. Court W, Reynolds B, Hendel J. Influence of root age on the concentration of ginsenosides of American ginseng (*Panax quinquefolium*). Can J Plant Sci 1996; 76:853-5.
3. Kołota E, Osińska M. Ocena przydatności Ekolistu do nawożenia dolistnego warzyw w uprawie polowej. Biul Warzyw 1994; 65:49-65.
4. Kołodziej B. The effect of Atonik and foliar fertilization on American ginseng (*Panax quinquefolium* L.) yielding and raw material quality. Annales UMCS 2004; sec. E, 59 (1):157-62.
5. Jabłoński K. Nawozy dolistne w uprawie ziemniaków. Por Gosp 1998; 6:25-6.
6. Jabłoński K. Agrotechniczne i ekonomiczne efekty dolistnego nawożenia ziemniaków. Por Gosp 2000; 7/8:14-15.
7. Jabłoński K. Korzyści z dolistnego nawożenia ziemniaków mikroelementami. Ziemn Pol 2002; 2:22-9.
8. Berbec S, Andruszczak S, Łusiak J, Sapko A. Wpływ dolistnego stosowania Atoniku i Ekolistu na plony i jakość surowca tymianku. Acta Agroph 2003; 85:305-11.
9. Biesiada A, Kołota E. Zastosowanie nawozów wieloskładnikowych do nawożenia dolistnego selera korzeniowego. Fol Univ Agric Stetin 1998; 190 Agric. (72):29-33.
10. Grześkiewicz H, Trawczyński C. Dolistne stosowanie nawozów wieloskładnikowych w uprawie ziemniaka. Fol Univ Agric Stetin 1998; 190 Agric. (72):75-80.

WPLYW NAWOŻENIA DOLISTNEGO NA PLONY I JAKOŚĆ KORZENI ŻEŃ-SZENIA  
AMERYKAŃSKIEGO (*PANAX QUINQUEFOLIUM* L.)

RAFAŁ MAGDZIAK, BARBARA KOŁODZIEJ\*

Katedra Roślin Przemysłowych i Leczniczych,  
Akademia Rolnicza,  
ul. Akademicka 15, 20-950 Lublin,

\*autor, do którego należy kierować korespondencję: tel.: +48 81 4456679, e-mail:  
barbara.kolodziej@ar.lublin.pl

Streszczenie

W czteroletnim doświadczeniu polowym badano wpływ dokarmiania dolistnego 1% roztworem Ekolistu i Mikrosolu U na plon i jakość korzeni żeń-szenia amerykańskiego (*Panax quinquefolium* L.). Dowiedziono, że wpływ obu preparatów na długość całkowitą i średnicę korzenia w pierwszym roku wegetacji był niewielki, uwidocznił się zaś w kolejnych latach wegetacji, powodując istotne zwiększenie plonów korzeni. Surowiec uzyskany z obiektów dokarmianych dolistnie odznaczał się także lepszą zdrowotnością i wyższą zawartością substancji czynnych. Spośród dwóch porównywanych preparatów korzystniejszy wpływ na badane cechy roślin wywarł Mikrosol U.

*Słowa kluczowe:* nawożenie dolistne, żeń-szeń amerykański, *Panax quinquefolium* L.