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POSSIBILITY OF GROWING ELECAMPANE IN CONDITIONS OF NON-WATERING FIELD CROP PRODUCTION

V. Filipović[1], R. Jevdjović[2], Dj. Glamočlija[3] and B. Jovanović[1]

Abstract: Intensively researching different populations of elecampane, we are able to present the results of yield achieved during three years' microexpiriments (2001, 2002, 2003) realized in non-watering field crop production. Comparing the results of yield, it was concluded that all five populations had higher yield, both fresh and dry elecampane root mass, compared to standard cultivar called ″Domaća″. The highest yield of 28,617 kg ha^{-1} of fresh, and 8,301 kg ha^{-1} of dry root had the population ″NŠ″, and it was more than standard. Considerable results were achieved by the population ″SŽ″ (77 % higher yield of fresh mass, and 70 % of dry mass), also the population ″BM″ (62 % higher yield of fresh mass, and 84 % of dry mass). The lowest yield had the population ″SG″ and standard cultivar ″Domaća″, mostly because of late planting in the second study year.

Key words: elecampane, yield, dry root, population, standard cultivar.

I n t r o d u c t i o n

Elecampane (*Inula helenium* L.) fam. *Asteraceae,* is a perennial, herbaceous plant, with strong, 60 – 200 cm high, stem and strong root. Leaves are alternate, egg shaped, with jagged edges covering the stem. The bulbs are 6 – 7 cm large in diameter. Blooming period is from June to October (Kojic and Pekic, 1995). It is widely spread, especially in wet places near rivers, forests, fields and sometimes in inhabited places (Diklic, 1995; Tucakov and Lukic, 1960).

[1] Vladimir Filipović, M.Sc., Bogdan Jovanović, M.Sc., PDS, Institute ″Tamiš″, Novoseljanski put 33, 26000 Pancevo, Serbia and Montenegro

[2] Radosav Jevdjović, M.Sc., Institute for Medicinal Plants Research ″Dr Josif Pančić″, T. Košćuška 1, 11000 Belgrade, Serbia and Montenegro

[3] Djordje Glamočlija, PhD., Professor, Faculty of Agriculture, Nemanjina 6, 11081 Belgrade – Zemun, Serbia and Montenegro

It is healing property is found in its meaty and large rhizome, wide roots (*Helenii rhizoma* or *Inulae radix*). It contains 1 – 3% of essential oil, sesquiterpene lactones (alantolacton and others) known as helenin or elecampane camphor (Wichtl, 1994; Jeftovic, 2001) which are crystal part of this oil. It contains sesquiterpene lactones – carabron (Milosavljevic, 1995) too. The essential oil sample and a hexane extract show antimicrobial activities (Bourrel et al., 1993). Elecampane roots contain a great number of active ingredients which have an extraordinary effect in medical therapy (Kovacevic, 1995). The root is dug out in the fall and is used fresh for extracts or syrup, dried for decoctions, liquid extracts, tinctures or powders. Flower heads are picked at full bloom and dried whole to use for infusions and powders. Flowers contain irritant fibers and should be prepared using a muslin bag. They could be used for teas and infusions only after analysis for heavy metal concentration in these products, particularly for the roots from *Inula helenium* (Zheljazkov and Fair, 1996).

In recent times elecampane cultivation is more and more frequent (Stepanovic et al., 2002). It prefers a sunny site with moist but well – drained clay loam soils and a pH of 4.5 – 7.0.

It is possible to mistake elecampane root for belladonna, dandelion and marsh mallow roots. Except similar root, elecampane and marsh mallow have some other similarities: the way of cultivation, use and quantity of yield (Jevdjovic et al., 2002; Filipovic, 2003).

Considering growing needs for elecampane root and knowing that natural resources are insufficient, cultivation is the main way of getting this raw material, especially when we know that the root of grown elecampane has standard quality and guaranteed yield.

Continuing the researches of Jevdjovic et al., (2004), the aim of this work was to find out the difference in elecampane root yield of a few populations and standard cultivar, using comparative research.

Material and Methods

For these researches we used elecampane plant (*Inula helenium* L.) grown and reproduced at the Institute for Research of Medicinal Herbs ″Dr Josif Pančić″ from Belgrade. The researches were conducted on five populations marked as: ″AB″, ″NŠ″, ″SŽ″, ″BM″ and ″SG″, which were compared to a standard cultivar ″Domaća″ that is very often cultivated in our country.

The researches were conducted as three years' micro-experiments during 2001, 2002 and 2003 in the South Banat area, on the marsh dark soil, near Pančevo. The seed of all populations and the standard cultivar was 98% of purity and 90% of sprouting. During the first two study years the seed was planted in a greenhouse in the third decade of February. The size of this experimental field was 10 m^2 and

we used it for calculations too. Field microexpiriments were set randomly by the block system design in four repetitions.

Temperature conditions during both study years were at the level of average as regards the quantity and distribution favorable for the development of plants in the field (table 1).

We can conclude that there were adverse climate conditions during the study period, mostly because of insufficient rainfall. The received meteorological data show long lasting dry period in the first two study years. It is a fact that both high temperatures and precipitation sum, during vegetation period and non-vegetation period, were significantly lower than the optimal conditions for South Banat area. Measured precipitation sum during June was insufficient for elecampane as a root plant to form a root (tables 1 and 2).

T a b. 1. - Distribution of temperature, mean daily temperature and sum of temperatures during vegetation season of 2002 and 2003

Month	Decades						Average daily temperature		Sum	
	I		II		III					
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
III	10.6	3.6	10.5	5.6	7.8	8.7	9.6	6.1	297.6	188.99
IV	8.7	6.8	12.9	12.4	15.8	15.9	12.5	11.7	375.0	351.15
V	19.8	23.8	21.4	20.8	22.9	20.5	20.7	21.6	641.0	670.85
VI	20.2	24.9	24.5	25.3	25.7	24.8	23.5	25.0	705.0	750.16
VII	26.0	23.3	26.5	21.8	23.1	24.9	25.1	23.3	778.1	722.54
VIII	24.3	24.7	21.0	25.5	22.5	25.3	22.6	24.2	700.6	780.49
IX	22.1	18.2	16.9	17.4	16.7	18.2	13.6	17.9	558.0	536.95
X	12.7	14.9	12.9	9.6	12.4	6.9	12.6	10.3	378.0	321.10

T a b. 2. - Distribution of precipitation, total precipitation and number of rainy days during vegetation season of 2002 and 2003

Month	Decades						Total precipitation		Number of rainy days	
	I		II		III					
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
III	5.1	0.0	2.9	9.2	4.2	0.0	12.2	9.2	6	3
IV	4.1	0.0	26.0	7.0	6.6	12.9	36.7	19.9	10	8
V	2.4	0.0	2.8	17.2	10.3	25.7	15.5	42.9	5	5
VI	8.1	5.6	6.9	10.6	5.5	0.0	20.5	16.2	7	4
VII	5.9	39.0	22.7	40.7	12.1	14.4	40.7	94.1	7	11
VIII	23.7	0.0	36.4	4.1	28.0	2.2	88.1	6.3	9	3
IX	0.0	19.3	7.2	41.5	64.2	5.0	71.4	65.8	9	8
X	8.9	38.7	36.6	0.4	44.4	71.2	89.9	110.3	13	16

Planting was done in the third decade of April, and the distance between the rows was 70 cm and between the plants in the row 30 cm. Each population and the standard cultivar were planted in four repetitions. During the second year, the population ″SG″ and the standard cultivar ″Domaća″ were planted later than it was optimal, which influenced yield. During the first year of cultivation, we used standard methods of cultivating, but at the end of vegetation period, the root wasn't dug out because it is not for use in the first year (Tucakov, 1997; Jeftovic, 2001; Jevdjovic et al., 2004). During the vegetation in the second year, we used the standard method of cultivation. Plants were not watered because we wanted to show the endurance of populations and standard cultivar, in fact, the reaction of plants in conditions of non-watering. We dug out the roots in the third decade of October. The root was cleaned, washed in cold water and cut in smaller pieces and then it was measured and left to dry. Drying was done at the temperature of 45 °C. The root humidity was reduced to 10% and then we measured the dry root.

The results of comparative experiments with 5 elecampane populations and standard cultivar were processed using statistical and mathematical methods of statistical variance by calculating average value, variance interval (I_v) and variance coefficient (C_v). Statistical significance of differences between investigated factors were calculated by the model of variance analysis. All statistical important data were calculated using F-test and LSD – test for the levels of significance of 5% and 1%.

Results and Discussion

The root and aboveground biomass yield depends, after all, on agrotechnical methods, but also on ecological factors and most of all precipitation. During two years' study period we concluded that elecampane as thermophile plant prefers high temperatures, but low level of rainfall during the study period resulted in yield decrease. The yield of investigated populations and the standard cultivar of elecampane root showed that the cultivation is possible using concrete experimental methods (table 3).

The obtained results for average values of elecampane root biomass show heterogeneity of investigated populations and standards, causing very significant statistical differences. During the first study year, the variance interval, on average, was 22,734 kg/ha of fresh root biomass, which shows a great variation (C_v=53.2%). Heterogeneity of investigated populations was also confirmed in the year 2003, when average fresh and dry root biomasses had shown significant dispersion of populations (C_v=56.9 % fresh and C_v=48.7 % dry).

Variance analysis had shown the significance of fresh and dry root biomass difference between populations and study years, but also the significance of

differences in characteristics, when both factors influence simultaneously (table 4).

T a b. 3. - Yield and correlation of fresh and dry root of tested population and standard cultivar

Population	Fresh weight (kg/ha)			Dry weight (kg/ha)			Fresh : Dry
	2002	2003	Average	2002	2003	Average	
″AB″	13,804	15,523	14,664	3,808	4,566	4,187	3.5 : 1
″NŠ″	22,432	34,802	28,617	7,356	9,245	8,301	3.5 : 1
″SŽ″	16,248	34,057	25,153	4,551	8,398	6,475	3.9 : 1
″BM″	20,825	24,950	22,888	6,247	7,796	7,022	3.3 : 1
″SG″	19,802	16,627	18,215	5,570	5,211	5,391	3.4 : 1
Standard cultivar ″Domaća″	16,232	12,059	14,146	4,331	3,289	3,810	3.7 : 1
Average	18,224	23,003	20,613	5,311	6,418	5,864	3.5 : 1
I_v	6,200	22,734		3,548	5,956		
C_v (%)	53.2	56.9		56.3	48.7		

T a b. 4. - F – test values of the parametars analysed

Sources of variation	Freedom degree	F – values	
		Fresh weight	Dry weight
Year	1	3.6608^{ns}	0.5730^{ns}
Population	5	3.6928^{*}	6.2786^{**}
Interaction	5	2.0332^{ns}	0.4807^{ns}

^{ns} Statist. non significant
* significant at level of 5%
** significant at level of 1%

T a b. 5. - The levels of signification

Sources of variation	LSD	Population	Year	Interaction
Fresh weight	0.05	8,808.7	5,082.2	12,619.0
	0.01	11,826.0	6,827.7	16,575.7
Dry weight	0.05	2,308.0	1,332.5	3,271.8
	0.01	3,100.7	1,790.2	4,422.3

Statistically significant variations between the yields of 5 populations marked as ″AB″, ″NŠ″, ″SŽ″, ″BM″, ″SG″ and standard cultivar ″Domaća″ were noticed with both variables. The highest yield of fresh elecampane root was achieved with the populations ″NŠ″ and ″SŽ″, and it was two times higher compared with

the standard cultivar. The population ″BM″ produced high results too (62% higher yield compared to the standard cultivar). The variation of yield was the most significant and obvious with two best populations (″NŠ″ and ″SŽ″), where the difference between years was 12,370 kg ha^{-1} to 17,809 kg ha^{-1}. The lowest result (14,146 kg ha^{-1}) had the standard cultivar ″Domaća″, mostly because of late planting during the second study year. The populations ″AB″ and ″SG″ were less productive.

The statistics for dry root yield confirmed productivity order for fresh root. The only difference between two variables was with ″SŽ″ and ″BM″ populations, which changed places regarding the yield. Statistically significant variation of dry root yield was noticed between the standard cultivar ″Domaća″ and population ″AB″ and other populations. The highest yield of peeled dry root had the population ″NŠ″ and it was 2.2 times higher than the standard cultivar. Standard cultivar ″Domaća″ had the lowest result in both fresh and dry root (3,810 kg ha^{-1}). Considering the results for populations (″NŠ″ and ″SŽ″), we can notice statistically significant difference in two study years, which was 1,889 kg ha^{-1} and 3,847 kg ha^{-1} for elecampane dry root yield.

The interaction of investigated factors showed no statistical significance.

In numerous studies the most frequent relation between fresh and dry root is 4:1 (Milojevic et al., 1968). This relation can be accepted conditionally, especially if other criteria for determination of elecampane dry root quality are satisfactory (in production and processing). According to research data, the relation between raw and dry root goes from 3.3:1 to 4.0:1.

Conclusion

Considering two years' research and the analysis of research results, we can conclude:

The final yield results in the first year were lower than in the second study year probably as a result of insufficient rainfall.

Elecampane as a plant, which prefers warm conditions, can be grown in extensive agricultural conditions.

The studied populations have shown high degree of regenerative and productive capacity.

The future researches should be continued because of high level of active chemical ingredients in elecampane root.

The standard cultivar ″Domaća″ and population ″AB″ shouldn't be cultivated without irrigation.

The population ″NŠ″ should gradually be put in plantation production.

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ISPITIVANJE MOGUĆNOSTI GAJENJA OMANA U USLOVIMA SUVOG RATARENJA

V. Filipović[1], R. Jevdjović[2], Dj. Glamočlija[3] i B. Jovanović[1]

R e z i m e

U istraživanjima različitih populacija omana prikazani su rezultati prinosa korena, dobijeni kroz trogodišnje mikrooglede (2001., 2002. i 2003.) postavljene u uslovima suvog ratarenja. Upoređujući postignute prinose, došlo se do zaključka da je svih pet populacija imalo veći prinos, kako sveže tako suve mase korena omana u odnosu na standardnu sortu ″Domaća″. U dvogodišnjem proseku, najveći prinos od 28.617 kg ha^{-1} svežeg i 8.301 kg ha^{-1} suvog korena imala je populacija ″NŠ″, što je bilo više za 28 %, odnosno 29 % u poređenju na standard. Dobre rezultate su ostvarile i populacije ″SŽ″ (za 77 % veći prinos sveže i 70 % suve mase) kao i populacija ″BM″ (veći prinosi sveže i suve mase, za 62 %, odnosno 84 %). Najlošije prinose imale su populacija ″SG″ i standardna sorta ″Domaća″ pre svega zbog kasnijeg rasađivanja u drugoj godini istraživanja.

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[1] Mr Vladimir Filipović, mr Bogdan Jovanović, Institut ″Tamiš″, Novoseljanski put 33, 26000 Pančevo, Srbija i Crna Gora

[2] Mr Radosav Jevdjović, Institut za lekovito bilje ″Dr Josif Pančić″, T. Košćuška 1, 11000 Beograd, Srbija i Crna Gora

[3] Dr Djordje Glamočlija, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina 6, Srbija i Crna Gora