The effect of the method of plantation establishment on some morphological traits and yield of lovage roots (*Levisticum officinale* Koch.)

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S u m m a r y

The field experiment was carried out in Zamość on the brown soil of loess origin in 2002–2005. There were four methods of plantation establishment compared: 1) direct sowing in the field; 2) direct sowing in the field with cover of polypropylene sheet; 3) by seedlings from plastic house; 4) by seedlings produced in multi-cell propagation trays. It was found that lovage cultivated from seedlings was characterized by higher root neck diameter as well as greater number of root branches. As a consequence, the obtained yield of air dry roots mass was higher than in cultivation from direct seeding, but the most successful method of lovage plantation establishment was by seedlings produced in multi-cell propagation trays. The use of polypropylene sheet caused a significant decrease of air dry roots yield in the first year of plant vegetation, but did not have any significant influence on the root yield in the second year. Chemical analyses showed small differences in the essential oil content in the roots. The greatest content of active substances was found in the one-year old roots of the control objects.

Key words: lovage, Levisticum officinale Koch., method of plantation establishment, essential oil

Lovage is a perennial commonly cultivated in Poland. The roots and rhizome of plant, collected in autumn and containing over 0.7% of essential oil, are used as an ingredient of herbal mixtures with a diuretic and improving digestion properties, whereas in the food processing industry they are used in the manufacturing of bouillon cubes or liquid stock [1]. The method that nowadays is recommended for growing of lovage is sowing seeds directly to the field or planting seedlings. The increasing requirements of the food processing industry regarding the quality of the raw material necessitate searching for new methods of cultivation of this

species. In this context, it is worthwhile to consider the planting of seedlings produced in multi-cell propagation trays or use of polypropylene sheet to cover the soil immediately after sowing. Numerous articles dealing with other plant species indicate that the above-mentioned cultivation methods have a positive influence on the plants' development and, in consequence, on the yield obtained [2-6]. The aim of this study was to estimate the effect of the method of plantation establishment on some morphological traits and yield of lovage roots.

MATERIALS AND METHODS

Field experiments with one- and two-year-old lovage plants ('Amor' cultivar) were conducted in Zamość in 2002–2005 on brown soil of loess origin characterized by medium humus and magnesium content, a very high phosphorus and potassium content, and a neutral reaction. The following methods of plantation establishment were compared: 1) direct sowing in the field (control); 2) direct sowing in the field and covering with polypropylene sheet; 3) planting seedlings obtained from plastic tunel; 4) planting seedlings produced in plastic tunnel, in multi-cell propagation trays (multiplates). The experiment was performed using random blocks in four replications, on plots of 20 m^2 each. Every year the plots were divided into 2 halves, one of which was used for one-year-old plants while the other was assigned for two-year-old plants and was used in the following year. In the experiment, the following doses of mineral fertilizers were used ($kg \cdot ha^{-1}$): 70 N, 25 P, 90 K. In order to obtain seedlings, seeds were sown in a heated plastic tunnel in the middle of March, on a peat substrate on the field-patch as well as in multi-cell propagation trays filled with the same peat substrate. Seeds were sown in the field in mid-April. Immediately after the sowing, the designated plots were covered with polypropylene sheet that was later removed when the plants reached the height of 15 cm. The seedlings were transplanted to the field in early May. For all objects the row spacing of 50 x 40 cm was applied. Each year, at the beginning of September, the roots were dug out, cleaned and rinsed, and then weighed. Next, the root neck diameter and the number of lateral roots (per 1 plant) were determined. After drying the collected root samples (at a temperature of 35°C), the content of air dry matter was determined and the yield of air dry roots was calculated. The essential oil content was determined in the roots using the steam distillation in the Deryng's apparatus [7]. The results of the experiment were verified statistically and the least significant differences were calculated using Tukey's confidence intervals with a 5% margin of error.

RESULTS AND DISCUSSION

The method of plantation establishment had a significant impact on the morphological traits of lovage roots (Table 1). Both in the first and second year of vegetation, a higher fresh root mass was achieved by plants grown from seed-

lings rather than from direct sowing. The greatest root mass was obtained when seedlings were produced in multi-cell propagation trays (439 and 457 g per plant in the first and second year of cultivation, respectively), while the smallest weight was found in the case of plants grown from seeds and covered with fibre (185 and 327 g per plant). Characteristically, in the first year of vegetation, there was a large and statistically significant difference regarding the fresh root weight between the control object and the object where polypropylene sheet was used, whereas in the second year no significant differences between these objects were found. The results achieved do not confirm the results of research conducted by Słodkowski [4] and Wadas [6] who found that using polypropylene sheet increased the weight of radish roots and potato bulbs. According to Lutomirska [3], good thermal and humidity conditions in covered soil not only facilitate the development of cultivated plants, but also the germination of weeds, which was observed in our experiment. Research conducted by Formanowiczowa [8] and the author's own observations indicate that the development of lovage, from the emergence to the formation of the leaf rosette, is quite slow, which reduces the cultivated plant's chances in competing for nutrients and water with the much faster developing weeds. In consequence, in the first year of vegetation, a significantly higher fresh root mass was generated by plants growing on plots without polypropylene sheet.

Table 1.

Morphological traits of lovage roots mean for years 2002–2004 (one-year-old plants) and 2003–2005 (two-year-old plants).

objects	fresh root weight (g per plant)		root neck diameter (mm)		number of root branches	
	1	2	1	2	1	2
sowing in the field (control object)	228	336	49	59	10,9	11,9
sowing in the field + covering with polypropylene	185	327	47	64	8,9	11,2
seedlings from plastic tunnel	361	400	61	66	19,2	22,9
seedlings from multiplates	439	457	66	69	22,5	22,7
mean	303	380	56	65	15,4	17,2
$NIR_{0.05}$	21	30	4	8	2,3	2,7

1. one-year-old plants 2. two-year-old plants

Compared with the control object, the plants grown from seedlings were characterised by significantly greater root neck diameter, but the biggest diameter was found when the plantation was established from seedlings produced in multiplates (66 and 69 mm in the first and second year of vegetation, respectively). Considering the number of lateral roots, it was found that the plants grown from seedlings had twice as many roots as the plants grown from seeds sown directly in the field. The above relationship comes probably from damage of root system while planting the seedlings in the field. In consequence, the initially developed taproot was transformed into the fibrous root system. Similar results were ob-

tained by Andruszczak and Wiśniewski [2] and Sugier [5], who found that marshmallow and dandelion plants cultivated from seedlings were characterized by an increased root neck diameter and a higher capacity to form lateral roots in comparison with plants grown from seeds sown directly in the field.

In the first year of cultivation, the yield of air dry root mass was significantly affected by the method of plantation establishment (Fig. 1). The lowest yield of air dry matter of root was obtained in the case of plants grown from seeds with the use of polypropylene sheet (2.53 t/ha^{-1}). A much higher yield (on average by 78.7% in relation to the control object) was recorded in plots where seedlings were planted. It must be emphasized, however, that plants cultivated from seedlings produced in multi-cell propagation trays gave significantly higher yield (by 26.2%) in comparison with seedlings obtained from plastic tunnel. In the second year of vegetation, the method of seedling production had no significant influence on the yield of air dry roots (the yield obtained from plots with seedlings produced in plastic tunnel and seedlings produced in multiplates was similar and significantly higher than in the control by 38%). Contrary to expectations, a lower yield of air dry roots was found in the case of two-year-old plants (independently of the method of establishing the plantation, by 0.52 t/ha^{-1} in relation to the one-year-old plants). It can be supposed that the low dry matter content in two-year-old roots was caused by the loss of most of plant's leaves during the fruiting stage, which slowed down photosynthesis process and, in consequence, had a negative effect on the dry matter accumulation in the raw material. However, it seems that the short period of time in which the experiment was conducted does not allow final conclusions. Therefore it is worthwhile to conduct further experiments on this issue.

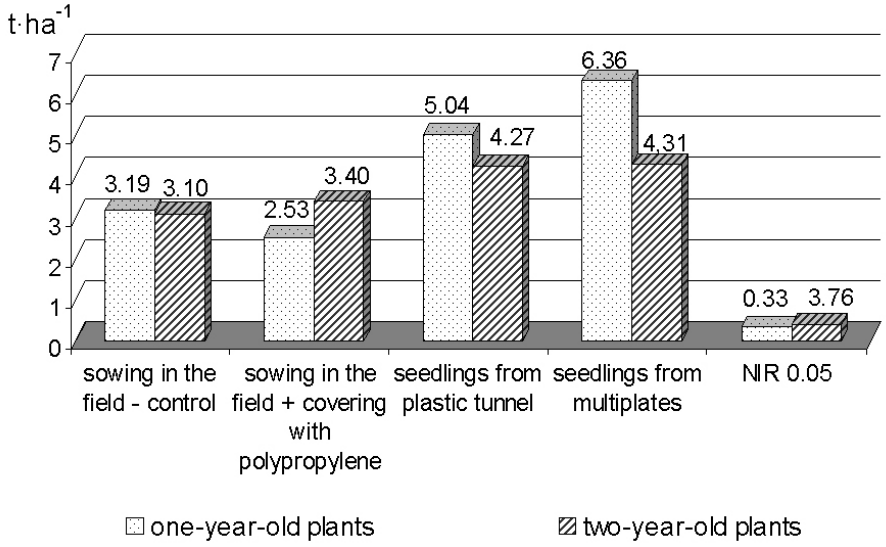

Fig. 1. Yield of air dry lovage roots. Mean for years 2002–2004 (one-year-old plants) and 2003–2005 (two-year-old plants).

Chemical analyses of roots of one-year-old plants indicated that the examined methods of establishing the plantation contributed to decrease of essential oil content in the roots (in relation to the control object) and that the cultivation of lovage from seedlings produced in multiplates was the least advantageous (essential oil content was 0.78% compared to 0.93% in the roots of control plants, see Tab. 2). In the second year of vegetation, the essential oil content in roots ranged from 0.77% in the case of control plants to 0.82% in the case of the plants grown from seeds with the use of polypropylene cover. Szebeni-Galambosi and Galambosi [9] found that the oil content in lovage roots increases as plants become older. A similar opinion is expressed by Novak and Nemeth [10] as well as Novak et al. [11] who found that the roots of older plants were more valuable with regard to the essential oil content. In this experiment an opposite result was observed because two-year-old roots were characterised by slightly lower oil content than the roots of one-year-old plants.

Table 2.

Essential oil content in lovage roots. Mean for years 2002–2004 (one-year-old plants) and 2003–2005 (two-year-old plants).

objects	one-year-old plants		two-year-old plants	
	%	in relative numbers	%	in relative numbers
sowing in the field (control object)	0.93	100	0.77	100
sowing in the field + covering with polypropylene	0.83	89	0.82	106
seedlings from plastic tunnel	0.79	85	0.78	101
seedlings from multiplates	0.78	84	0.78	101
mean	0.83		0.79	

CONCLUSIONS

1. Plants grown from seedlings were characterized by a bigger root neck diameter, higher capacity to form lateral roots and higher fresh root weight in comparison with plants grown from direct sowing in the field.
2. A higher yield of the air dry roots was found in the case of plants grown from seedlings rather than from direct sowing in the field, but the most successful method of establishing the plantation was planting seedlings produced in multi-cell propagation trays.
3. Using polypropylene sheet for covering the plants negatively affected the yield of air dry roots in the first year of vegetation, but had no significant effect on yielding of two-year-old plants.
4. The highest essential oil content in one-year-old roots was achieved when the plants were grown from seeds, whereas in the second year of vegetation the most advantageous with regard to the oil content was direct sowing to the field and covering with polypropylene sheet.

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WPŁYW SPOSOBU ZAKŁADANIA PLANTACJI NA WYBRANE CECHY MORFOLOGICZNE I PLON KORZENI LUBCZYKU OGRODOWEGO (*LEVISTICUM OFFICINALE* KOCH.)

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S t r e s z c z e n i e

Doświadczenie polowe przeprowadzono w latach 2002–2005 w Zamościu na glebie brunatnej pochodzenia lessowego. Porównywano następujące sposoby zakładania plantacji: 1) wysiew nasion wprost do gruntu – obiekt kontrolny; 2) wysiew nasion wprost do gruntu z zastosowaniem agrowłókniny; 3) wysadzanie rozsady uzyskanej w tunelu foliowym; 4) wysadzanie rozsady wyprodukowanej w tacach wielokomórkowych w tunelu foliowym. Stwierdzono, że, w porównaniu z siewem nasion wprost do gruntu, rośliny uprawiane z rozsady charakteryzowały się większą średnicą szyjki korzeniowej oraz większą zdolnością wytwarzania korzeni bocznych, a w konsekwencji również wyższym plonem surowca. Zarówno w pierwszym, jak i w drugim roku wegetacji największą świeżą i powietrznie suchą masę korzeni wytworzyły rośliny na obiekcie z rozsadą produkowaną w tacach wielokomórkowych. Zastosowanie agrowłókniny istotnie zmniejszyło masę ko-

rzeni w pierwszym roku wegetacji, nie miało zaś wpływu na wielkość plonu surowca dwuletniego. Analizy chemiczne wykazały małe zróżnicowanie zawartości olejku eterycznego w korzeniach. Najwięcej substancji czynnej gromadziły rośliny jednoroczne na poletkach kontrolnych.

Słowa kluczowe: lubczyk ogrodowy, Levisticum officinale Koch., sposób zakładania plantacji, olejek eteryczny