Germination and emergence of prickly lettuce (*Lactuca serriola* L.) and its susceptibility to selected herbicides

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ABSTRACT

Three-year trials were conducted to study germination and emergence of prickly lettuce (*Lactuca serriola* L.) achenes, increments of shoot dry matter and susceptibility of the weed to selected herbicides. The germination rates of achenes at 10°C (92%), 20°C (97%) and 30°C (95%) did not indicate any significant differences within 20 days from sowing. The highest percentage emergence of prickly lettuce achenes was determined after their sowing into a depth of 1 mm. Differences from the variants of sowing onto the soil surface (0 mm), into a depth of 10 and 20 mm were significant. There were no differences in the emergence rates from a depth of 10 and 20 mm. The highest increments of shoot dry matter were observed when prickly lettuce plants were grown for 4–7 weeks after sowing at 20°C. The effect of selected herbicides on prickly lettuce plants treated at the stage of 2–3 true leaves was evaluated on the basis of a change in the content of shoot dry matter. A significant decrease in dry matter against the control was recorded in all variants after herbicide application. The effect (expressed by a lower dry matter content) was significantly higher after the combination amidosulfuron + iodosulfuron-methyl + mefenpyr-diethyl (10 + 2.5 + 25 g/ha) was used than after the application of tribenuron (10.85 g/ha) and picolinafen + cyanazine (120 g + 480 h). The effect of amidosulfuron (22.5 g/ha) was significantly higher than in the variants treated with tribenuron, picloram + clopyralid (16.75 + 66.75 g/ha), clopyralid (90 g/ha) and picolinafen + cyanazine (150 + 600 g/ha). The best effects were produced by herbicides containing amidosulfuron and iodosulfuron as active ingredients.

Keywords: *Lactuca serriola* L.; germination; emergence; dry matter; susceptibility to herbicides

Prickly lettuce (*Lactuca serriola* L.), which used to be an unimportant weed in fields (Prince and Carter 1985), has recently spread in the whole territory of the Czech Republic. Currently, this weed occurs in all crops where it is a competitive plant due to its sizeable shoots and roots. Plants produce huge amounts of achenes carried by wind, so the expansion of this weed is fast. This is the reason why its biology and control should be paid attention to. It is accentuated by a finding from 1987 of a sulfonylurea-resistant biotype of prickly lettuce in wheat in the USA (Alcocer-Ruthling et al. 1992a). The weed was discovered on a farm near a motorway where intensive applications of sulfometuron were carried out. Based on the results (Mallory-Smith et al. 1992), it was concluded that the sulfonylurea resistant of prickly lettuce were not less competitive than the sensitive biotype.

The risk of occurrence of this resistant biotype could be imminent also in this country in future. In the Czech Republic, the occurrence of kochia (*Kochia scoparia* L.) with this type of resistance to acetolactate synthase inhibitors was proved (Chodová and Mikulka 2000, 2002, Mikulka and Chodová 2000).

This paper presents the results of three-year trials aimed at prickly lettuce germination at three temperatures 10, 20 and 30°C and emergence from four sowing depths. Seeds of prickly lettuce do not undergo dormancy and germinate soon while their germination is at maximum in early winter or late spring (Marks and Prince 1981). Viable seed is maintained in the soil for 3 years (Marks and Prince 1982). Suitable temperature for the growth of prickly lettuce and its susceptibility to selected herbicides were also studied in three-year trials.

MATERIAL AND METHODS

Plant material. Seeds of prickly lettuce (*Lactuca serriola* L.) were collected from 10th to 15th September in 1999, 2000 and 2001 on experimental plots of the Research Institute of Crop Production where no herbicides have ever been applied. Seeds from the autumn collection were stored at 5°C for a trial that was carried out in the next year (March to May).

Germination. Achenes of prickly lettuce germinated at 10, 20 and 30°C (photoperiod 12 hours dark and 12 hours light) on filter paper in Petri dishes 10 cm in diameter. The paper was moistened with 5 ml of distilled water. Germination (radicles were longer that the seed diameter) was evaluated every day. Twenty-five achenes per dish were used; germinating achenes were removed from dishes.

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Table 1. Percentage germination of prickly lettuce (*Lactuca serriola*) achenes in 20 days after sowing at temperatures 10, 20 and 30°C

Days after sowing	Temperatures (°C) 10	20	30
1	0	78	13
2	0	93	25
3	9	97	62
4	47	97	85
5	90	97	86
6	91	97	91
7	92	97	94
8	92	97	95
9	92	97	95
10	92	97	95
11	92	97	95
12	92	97	95
13	92	97	95
14	92	97	95
15	92	97	95
16	92	97	95
17	92	97	95
18	92	97	95
19	92	97	95
20	92	97	95

Total of 100 achenes were germinated in one trial. The values are averages of four replications, and they were evaluated by *t*-test ($P > 0.05$, significant difference) in 20 days after sowing. Prickly lettuce germination at 30°C was represented graphically and a regression curve was plotted.

Emergence. Achenes were sown into containers 10 × 10 cm in size filled with substrate (a mixture of topsoil and potting substrate, pH 6.8 at a 1:1 ratio). Thirty achenes were sown per container, either onto the soil surface (0 mm) or the seeds were covered with soil to a depth of 1 mm (with finely sieved substrate). PVC frames 10 and 20 mm high were inserted into containers filled with substrate 10–20 mm under the container brim and the seeds were evenly covered with sieved substrate to the frame brim. Containers were placed in a climatic box at a temperature of 20°C, humidity 65–80%, and photoperiod 12 hours dark and 12 hours light. Emergence of 120 seeds was evaluated for each sowing depth in one trial; the trial had four replications (total 480 achenes). The results were evaluated by *t*-test ($P > 0.05$, significant difference) in 20 days after sowing. The course of emergence within the first 10 days was represented graphically.

Table 2. Evaluation of differences in the germination of prickly lettuce (*Lactuca serriola*) achenes in 20 days after sowing at temperatures 10, 20 and 30°C

Differences between variants (°C)	Differences in means (% germination)	Calculated test value (*t*)	*t*-significance at 95%
10–20	92–97	1.21	non significant
10–30	92–95	0.70	non significant
20–30	97–95	0.74	non significant

Prickly lettuce dry matter. Prickly lettuce dry matter was evaluated in weekly intervals in plants grown at 10, 20 and 30°C. Plants were grown in a climatic box in containers 15 × 15 cm in size in the substrate as described in the paragraph Emergence. Fifteen seeds (collected in 2000) were planted per container, and after emergence, the number of plants was reduced to 10. Shoots were collected in weakly intervals (all plants in container) in 4, 5, 6 and 7 weeks after sowing. Dry matter was determined at 75–78°C. Forty plants were evaluated in one trial, the trial had three replications. The values of dry matter are represented graphically.

Herbicide applications. Achenes were sown into containers 10 × 10 cm in size filled with substrate (a mixture

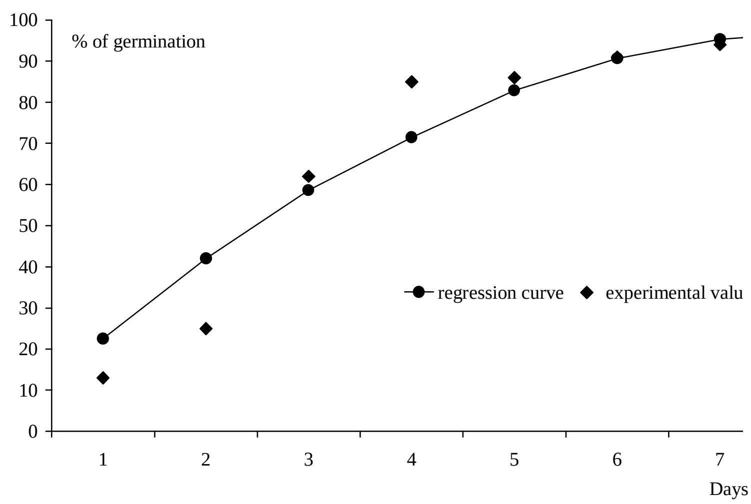

Figure 1. Germination of prickly lettuce (*Lactuca serriola*) achenes at 30°C
Regression equations expressing the correlation between the number of days after sowing and percentage germination of prickly lettuce at 30°C: $y = 23.98x - 1.48x^2$

Table 3. Average % emergence of prickly lettuce (*Lactuca serriola*) in 20 days after achenes were sown into various depths

Days after sowing	Depth of sowing (mm) 0	1	10	20
6	3.00	7.00	0	0
7	8.75	18.50	0	1.00
8	20.00	32.00	2.00	2.00
9	28.00	44.25	2.00	3.00
10	48.00	77.00	15.75	8.25
11	50.50	79.50	19.00	11.50
12	52.00	81.50	20.50	13.00
13	56.00	82.50	20.50	14.00
14	56.50	83.50	20.50	16.50
15	57.50	86.50	22.25	18.00
16	58.75	86.50	22.25	19.00
17	59.25	86.50	24.00	20.00
18	59.25	86.50	24.50	20.00
19	59.25	86.50	24.50	20.00
20	59.25	86.50	24.50	20.00

of topsoil and potting substrate, pH 6.8 at 1:1 ratio) – 0.1 g seeds per container; the number of plants was thinned to ten individuals after their emergence. Standard growing conditions were used: temperature 22–24°C, illumination with fluorescent lamps 130 µmol/m^2/s, humidity 65–80%, photoperiod of 12-hour darkness. In two weeks after sowing plants at the stage of 2–3 true leaves were treated with herbicides (Table 5) using a laboratory sprayer and a water amount of 50 ml/m^2. Plant shoots were collected in two weeks after treatment and dry matter content was determined. The trial was repeated in 1999, 2000 and 2001. Forty plants were evaluated in one trial. The results were evaluated by analysis of variance ANOVA (minimum difference was determined by Tukey's test).

RESULTS AND DISCUSSION

Tables 1 and 2 and Figure 1 show the results of three-year trials aimed at germination of prickly lettuce achenes. Table 1 shows % germination of prickly lettuce achenes at temperatures of 10, 20 and 30°C for 20 days. Then the achenes did not germinate any longer. Alcocer-Ruthling et al. (1992b) also reported the high germination of prickly lettuce, almost 100% of achenes germinated at 24°C for 7 days. The finding of Thill et al. (1991) that prickly lettuce germinates within a wide range of temperatures was also confirmed. The temperature of 20°C is optimum for the germination of prickly lettuce achenes because 92% of seeds germinated. 92% of seeds germinate at 10°C and 95% at 30°C (Table 1). A comparison of differences between the variants (Table 2) indicated that the differences in achene germination between the three temperatures under study were not significant. It is certain that a wide temperature range of prickly lettuce germination contributes to its spread. Germination rate of prickly lettuce achenes amounted to 92% in the light and dark in a temperature range of 20–30°C (Colquhoun et al. 2001). Seeds of prickly lettuce from sulfonylurea resistant biotype plants germinated as fast or faster than seeds from sensitive plants (Alcocer-Ruthling et al. 1992b).

The germination of prickly lettuce achenes at 30°C was represented graphically and compared with the graph of regression (Figure 1). The shape of regression line is a curve steeply ascending within 5 days after sowing; its ascension between day 5 and 8 is moderate. The experimental values approximate the values smoothed in the regression line. A slight deviation was observed in the values in the first two days after sowing. Table 3 shows prickly lettuce germination from various depths of sowing; statistical evaluation of differences is given in Table 4.

Dynamics of emergence of prickly lettuce achenes from various sowing depths is illustrated in Figure 2. The highest emergence of prickly lettuce achenes was determined after sowing onto the soil surface (0 mm) and into a sowing depth of 1 mm; the difference from sowing onto the soil surface and into depths of 10 and 20 mm was significant. This fact can influence the emergence of prickly lettuce very favorably in localities with little substrate, e.g. on communications and roads of different types. Interesting is the finding of Mallory-Smith et al. (1990) that a resistant biotype of prickly lettuce was discovered in localities where a zero-tillage system in wheat was used. It is stated that most seeds are buried at a depth to 10 mm in zero-tillage system (Benech-Arnold et al. 2000). It is stated that seeds maintain their germinability in the soil for 3 years (Colquhoun et al. 2001). Prickly lettuce seeds germinated in legume crops where a system of one cut per year and mulching was used. The seedlings were capable of overwintering (Brant et al. 2000).

The growth of prickly lettuce was evaluated at three temperatures 10, 20 and 30°C and is represented in Figure 3. Dry matter increments of prickly lettuce shoots in % were evaluated (100% = prickly lettuce dry matter at 20°C). Shoot increments are optimum at 20°C; the temperatures of 10 and 30°C are not suitable for prickly lettuce growth.

Table 4. Evaluation of differences in prickly lettuce (*Lactuca serriola*) germination in 20 days after achenes were sown into various depths

Differences between variants (mm)	Differences in means (% germination)	Calculated test value (t)	t-significance at 95%
0–1	89–88	5.27	significant
0–10	59–25	6.71	significant
0–20	59–20	7.47	significant
1–10	88–25	17.58	significant
1–20	88–20	17.91	significant
10–20	25–20	1.60	non significant

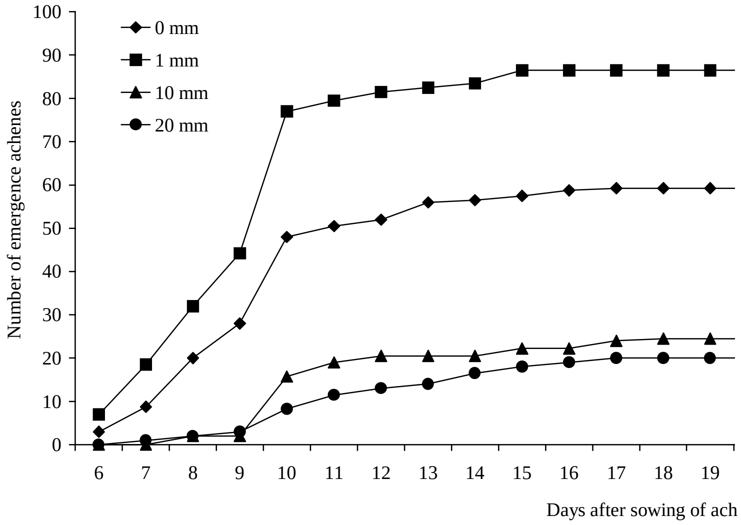

Figure 2. Emergence of prickly lettuce (*Lactuca serriola*) achenes in % from various depths of sowing (0, 1, 10 and 20 mm) in 20 days after sowing

Susceptibility of prickly lettuce was evaluated based on shoot dry matter content in comparison with control after applications of selected herbicides. The results including statistical evaluation are shown in Tables 5 and 6.

In two weeks after treatment, the values of dry matter in all treated variants were significantly lower than in the control. A significantly lower dry matter content was determined in the variant treated with the combination of amidosulfuron + iodosulfuron-methyl + mefenpyr-diethyl (10 + 2.5 + 25 g/ha) in comparison with the variant treated with picolinafen + cyanazine (150 + 600 g/ha) and tribenuron (10.85 g/ha). The effect of amidosulfuron (22.5 g/ha) was reflected in a significantly lower dry matter content than in the variants treated with tribenuron (10.85 g/ha), picloram + clopyralid (26.8 + 106.8 g/ha and 16.75 + 66.75 g/ha), clopyralid (90 g/ha) and picolinafen + cyanazine (120 + 480 g/ha). The lowest content of dry matter evaluated as percent of the control was determined in variants treated with amidosulfuron and amidosulfuron + iodosulfuron-methyl + mefenpyr-diethyl.

All plants died in two weeks after treatment in these variants: tribenuron, florasulam + 2,4-D, picloram + clopyralid (after application of both doses), clopyralid, iodosulfuron-methyl + mefenpyr-diethyl. Plants were strongly wilted after treatment with the other herbicides.

According to Kay and McMillan (1990), prickly lettuce is susceptible to photosystem II inhibitors (simazine, cyanazine, prometryn and metribuzin). Taking into account the occurrence of weeds resistant to these substances in this territory and the fact that resistance to these herbicides could originate (Mikulka and Chodová 2000), we do not recommend to use these chemicals alone, but only in a combination such as cyanazine + picolinafen. Besides the high effect of 2,4-D on prickly lettuce that was confirmed, the weed is reported to be susceptible to paraquat and oxyfluorfen (Colquhoun et al. 2001). Tank mixture of glyphosate + metsulfuron or 2,4-D ester were effective, giving of 68% control on prickly lettuce (Leys et al. 1990). Among 11 kinds of seeds used to bioassay the toxicity of butachlor, that of prickly lettuce was the most sensitive (Yeh and Huang 1996).

High growth vigour of the weed is documented by Brant et al. (2001). The plants, that were cut two times when the stems were 20–30 cm long, developed 50 cm long stems till the end of the vegetation. The plants cut once in the beginning of the generative stage developed 61 cm long stems.

Attention should be paid to the control of this weed because it is a host of important viral and fungal diseases (Simay 1993).

Very high germination of prickly lettuce achenes in a wide range of temperatures contributes to its spread and soil infestation. High emergence of achenes particularly from shallow depths of 0 and 1 mm could practically

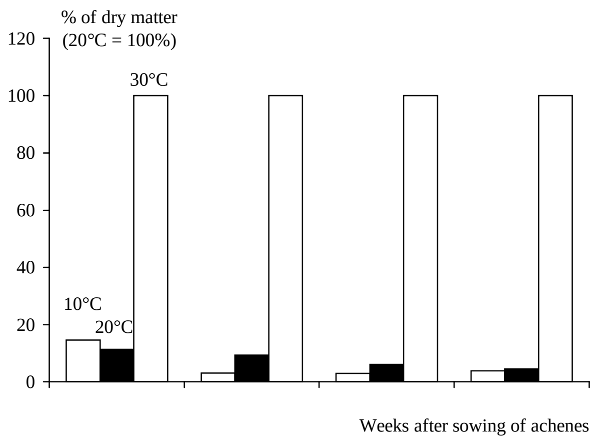

Figure 3. Dry matter content of prickly lettuce (*Lactuca serriola*) shoots grown at 10, 20 and 30°C for 4–7 weeks after sowing

Table 5. Dry matter content in mg/plant and in % of untreated control in shoots of prickly lettuce (*Lactuca serriola*) after herbicide treatment at the stage of 2–3 true leaves

Variant No.	Herbicide	Active ingredients	Doses of active ingredients/ha	Dry matter (mg)	% of control
1	Granstar 75 WG	tribenuron	10.85 g	35.0	32.9
2	Mustang	florasulam + 2,4-D	3.12 g + 150 g	27.0	25.4
3	Galera	picloram + clopyralid	16.75 g + 66.75 g	31.7	29.8
4	Galera	picloram + clopyralid	26.8 g + 106.8 g	30.0	28.2
5	Esteron 60	2,4-D	676.8 g	21.0	19.7
6	Lontrel 300	clopyralid	90 g	33.0	31.0
7	Grodyl 75 WG	amidosulfuron	22.5 g	9.7	9.1
8	Starane 250 EC	fluroxypyr	200 g	29.3	27.5
9	Husar	iodosulfuron-methyl + mefenpyr-diethyl	7.5 g + 18 g	16.3	15.3
10	Outlook WG	picolinafen + cyanazine	120 g + 480 g	35.3	33.2
11	Sekator	amidosulfuron + iodosulfuron-methyl + mefenpyr-diethyl	10 g + 2.5 g + 25 g	13.7	12.8
12	control	without treatment		106.3	100

be reduced by appropriate soil tillage, mainly by ploughing. All tested herbicides containing different active ingredients were effective enough in the control of prickly lettuce (effect expressed by dry matter content). The highest effect was observed after applications of active ingredients with amidosulfuron and iodosulfuron content.

Table 6. The significant differences in the dry matter of prickly lettuce (*Lactuca serriola*) shoots

Compared variants	Difference
12/1	71.3
12/2	79.3
12/3	74.6
12/4	76.3
12/5	85.3
12/6	73.3
12/7	96.6
12/8	77.0
12/9	90.0
12/10	71.0
12/11	92.6
7/1	25.3
7/3	22.0
7/6	23.3
7/10	25.6
10/11	21.6
11/1	21.3

Variants No. see Table 5
ANOVA *LSD* (0.05) = 20.3 = min. difference (Tukey's test)

REFERENCES

Alcocer-Ruthling M., Thill D.C., Mallory-Smith C.A. (1992a): Monitoring the occurrence of sulfonylurea-resistant prickly lettuce (*Lactuca serriola*). Weed Technol., *6*: 437–440.

Alcocer-Ruthling M., Thill D.C., Shafii B. (1992b): Seed biology of sulfonylurea-resistant and -susceptible biotypes of prickly lettuce (*Lactuca serriola*). Weed Technol., *6*: 858–864.

Benech-Arnold R.L., Sánechez R.A., Forcella F., Kruk B.C., Ghersa C.M. (2000): Environmental control of dormancy in weed seed banks in soil. Field Crops Res., *67*: 105–122.

Brant V., Šantrůček J., Svobodová M. (2000): Einfluss der Bewirtschaftung von Stillegungsflächen auf die Verunkrautung. Z. Pfl.-Krankh. Pfl.-Schutz., *17*: 105–112.

Brant V., Svobodová M., Šantrůček J. (2001): *Lactuca serriola* L. presence on the set- side soil. Rostl. Výr., *47*: 63–69.

Chodová D., Mikulka J. (2000): Identification of resistance to imazapyr and cross resistance to selected sulfonylurea herbicides in *Kochia scoparia*. Z. Pfl.-Krankh. Pfl.-Schutz., *17*: 383–388.

Chodová D., Mikulka J. (2002): Differences in germination and emergence rates of kochia (*Kochia scoparia*) resistant and sensitive to chlorsulfuron and atrazine. Z. Pfl.-Krankh. Pfl.-Schutz., *18*: 213–218.

Colquhoun J., Brewster B., Mallory-Smith C. (2001): Weed management in mint. Oregon St. Univ. Ext. Publ., No. EM 8774.

Kay G., McMillan M.G. (1990): Pre- and post-emergence herbicides in chickpeas. II. Weed control. Proc. 9th Austral. Weeds Conf.: 44–48.

Leys A.R., Barnett A.G., Plater B. (1990): Evaluation of herbicides for control of summer growing weeds on fallows in south-eastern Australia. Austral. J. Exp. Agric., *30*: 270–279.

Mallory-Smith C.A., Thill D.C., Alcocer-Ruthling M., Thompson C.R. (1992): Proc. 1st Int. Weed Control Congr., *2*: 301–303.

Mallory-Smith C.A., Thill D.C., Dial M.J. (1990): Identification of sulfonylureas herbicide-resistant prickly lettuce (*Lactuca serriola*). Weed Technol., *4*: 163–168.

Marks M., Prince S. (1981): Influence of germination date on survival and fecundity in wild lettuce, *Lactuca serriola*. Oikos, *36*: 326–330.

Marks M., Prince S.D. (1982): Seed physiology and seasonal emergence of wild lettuce, *Lactuca serriola*. Oikos, *38*: 242–249.

Mikulka J., Chodová D. (2000): Long-term study on the occurrence of weeds resistant to herbicides on the Czech Republic. Z. Pfl.-Krankh. Pfl.-Schutz., *17*: 373–376.

Prince S.D., Carter R.N. (1985): The geographical distribution of prickly lettuce (*Lactuca serriola*). J. Ecol., *73*: 49–64.

Simay E.I. (1993): Incidence of rare microfungi observed in the Bidateteny and Cikota areas of Budapest. Mikologiai, *32*: 81–89.

Thill D.C., Mallory-Smith C.A., Saari L.L., Cotterman J.C., Primiani M.M., Saladini (1991): Sulfonylurea herbicide resistant weeds: Discovery, distribution, biology, mechanism and management. In: Caseley J.C., Cussans G.W., Atkins R.K. (eds.): Herbicide resistance in weeds and crops. Butterworth-Heinemann Lts., Oxford, England.

Yeh Y.L., Huang J.W. (1996): Effects of organic amendments on alleviating phytotoxicity of butachlor seedlings of garden peas. Plant Pathol. Bull., *5*: 33–37.

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ABSTRAKT

Klíčivost a vzcházivost lociky kompasové (*Lactuca serriola* L.) a její citlivost vůči vybraným herbicidům

V tříletých pokusech byla hodnocena klíčivost a vzcházivost nažek lociky kompasové (*Lactuca serriola* L.), přírůstky sušiny nadzemních částí a citlivost plevele vůči vybraným herbicidům. Nebyly zjištěny průkazné rozdíly v klíčivosti nažek při 10°C (92%), 20°C (97%) a 30°C (95%) po dobu 20 dní od jejich výsevu. Nejvyšší procento vzcházivosti nažek lociky kompasové bylo zjištěno při jejich výsevu do hloubky 1 mm. Rozdíly byly průkazné oproti variantě s výsevem nažek do hloubky 0 mm (na povrch půdy), 10 a 20 mm. Rozdíly ve vzcházivosti nažek z hloubky 10 a 20 mm nebyly zjištěny. Nejvyšší přírůstky sušiny nadzemních částí byly zjištěny při pěstování lociky kompasové po dobu 4–7 týdnů po výsevu při teplotě 20°C. Účinek vybraných herbicidů na lociku kompasovou, ošetřenou ve fázi 2–3 pravých listů, byl hodnocen změnou v obsahu sušiny nadzemních částí. Průkazné snížení sušiny bylo zjištěno u všech variant po ošetření herbicidem oproti kontrole. Průkazně vyšší účinek (vyjádřený nižším obsahem sušiny) byl po ošetření kombinací amidosulfuron + iodosulfuron-methyl + mefenpyr-diethyl (10 + 2,5 + 25 g/ha) oproti variantě ošetřené přípravky tribenuron (10,85 g/ha) a picolinafen + cyanazine (120 + 480 g/ha). Účinek amidosulfuronu (22,5 g/ha) byl průkazně vyšší oproti variantám ošetřeným přípravky tribenuron, picloram + clopyralid (16,75 + 66,75 g/ha), clopyralid (90 g/ha) a picolinafen + cyanazine (150 + 600 g/ha). Nejlepší účinek byl prokázán po aplikaci herbicidů, které obsahovaly účinné látky amidosulfuron a iodosulfuron.

Klíčová slova: *Lactuca serriola* L.; klíčivost; vzcházivost; sušina; citlivost vůči herbicidům

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