SHORT COMMUNICATION

Seed Emergence of Lucerne Varieties under Different Soil Conditions

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Abstract: The aim of this study was to examine in greenhouse experiments seed emergence of 14 lucerne varieties (mostly of the Czech origin) under different soil conditions (Luvisol, Chernozem and Cambisol). Soil conditions significantly influenced seed emergence in seven varieties. Their seed emergence was lower in Cambisol (72%) than in Chernozem (80%) and Luvisol (91%). In other varieties the soil effect was not significant. The effect of variety could not be separated from the effect of seed lot in our experiment. However, germination, occurrence of hard seeds, germinative energy and thousand-seed weight were not significantly different between the groups of varieties that could be classified as sensitive and tolerant to the examined soil conditions. The obtained results indicated that the selection of suitable lucerne variety or seed lot could be a tool for improving emergence in deteriorated soil conditions.

Keywords: germination; hard seed; lucerne; *Medicago sativa*; soil effect

Seed emergence of lucerne (*Medicago sativa* L.) is an important parameter connected with stand density, which is related to forage production (Hakl *et al.* 2011a). Lucerne seed emergence was widely investigated in relation to temperature (Sakanoue 2010), moisture (Wang *et al.* 1996), salinity (Al Doss 2011), seed size (Steppuhn *et al.* 2009), sowing depth (Townseed 1992) or light level (Wu *et al.* 2011). Nevertheless, there is a lack of information about lucerne seed emergence in different soils. In conditions of the Czech Republic, the lucerne growing is currently spreading into higher altitudes, often into worse soil conditions such as lower soil pH. The main reason for lucerne expansion is higher persistence and drought tolerance in comparison with red clover. Lucerne is more drought-tolerant than most of the other temperate forage legumes (Peterson *et al.* 1992), which is connected with the root development in specific environmental conditions (Annicchiarico *et al.* 2010).

The first problem of effective growing of lucerne under less favourable soil conditions is successful stand establishment, which is also related to sufficient seed emergence. Benabderrahim *et al.* (2011) demonstrated a significant effect of lucerne landrace and geographic origin on germination and field emergence. All Czech lucerne varieties have three national landraces (Hodonínka, Přerovská, Kaštická) in their pedigree, which were naturally differently influenced by sickle lucerne (*Medicago falcata* L.) considered as a genetic source for improving the adaptability of lucerne due to a higher tolerance to low pH (Jelinowska 1964). The origin of Czech varieties could be a source for different adaptability in contrast to foreign varieties. According to our opinion, the selection of suitable lucerne seed lots or varieties could improve the seed emergence especially in deteriorated soil conditions at higher altitudes. The aim of this study was to screen among 14 lucerne varieties for seed emergence under different soil conditions.

Seeds of 13 Czech lucerne varieties and the French variety Europe, which is also widely grown in the Czech Republic, were tested in spring 2011. All the seed samples originated from a harvest at the Želešice Breeding Station in 2006. In a Binder KBWF 240 climate chamber, the germination was assessed in Petri dishes on filter paper in 4 × 100 seeds per variety. The seeds were kept at 5°C in dark for 5 days and afterwards for 10 days under the 16/8 (light/dark) regime at 20°C. Germinative energy was expressed as the number of germinated seeds on the third day under the 16/8 regime at 20°C. Seeds without visible water intake after the entire process were evaluated as hard seeds and were counted to total germination. The weight of thousand seeds (WTS) was assessed from the weight of five hundred seeds in four replicates for each variety. As shown in Table 1, the examined varieties showed significant differences in all evaluated seed traits.

Seed emergence was tested in three soils which represent three main types of soil in the Czech Republic. Soil samples were taken from topsoil – A horizon in Haplic Luvisol, Haplic Chernozem and Haplic Cambisol. Soil types were determined according to the World Reference Base (IUSS Working Group WRB 2006). The basic chemical and physical soil properties were obtained using

Table 1. The means and variability of seed parameters in the evaluated lucerne varieties ($n = 4$) and their groups ($n = 28$)

Group	Variety	WTS (g)	Germinative energy (%)	Germination (%)	Occurrence of hard seeds (%)
SEN	Europe	1.98	18	76	13
	Jarka	2.12	65	91	3
	Litava	2.05	32	81	10
	Magda	2.12	57	86	7
	Oslava	2.10	58	93	8
	Pálava	2.18	55	94	6
	Tereza	2.12	42	77	3
TOL	Holyna	2.13	41	66	1
	Jitka	2.25	41	89	10
	Kamila	2.11	54	74	1
	Morava	2.05	59	91	4
	Niva	2.29	56	88	6
	Vlasta	1.97	40	85	9
	Zuzana	1.92	19	86	13
Between all	*P*	0.000	0.000	0.000	0.000
	LSD	0.09	31	14	6
SEN	mean	2.10	46	83	7
TOL	mean	2.10	43	84	6
Between group	*P*	0.880	0.607	0.591	0.416

SEN – sensitive to soil conditions, TOL – tolerant to soil conditions; WTS – weight of thousand seeds; one-way ANOVA, *P* is calculated between all varieties or their groups; LSD – least significant difference for Tukey HSD ($P < 0.05$)

standard laboratory procedures under a constant laboratory temperature of 20°C: soil pH (H_2O) and pH (KCl) (ISO 10390), soil salinity (Rhoades 1996) and particle size distribution (fractions of clay, silt and sand) (Gee & Or 2002). The basic characteristics of soil samples obtained from three locations are documented in Table 2. In each soil type a broadcast sowing of one hundred seeds on an area of 8 × 20 cm with four replicates was performed for each variety, using a randomized complete block design. The sowing depth was 1 cm. Seedlings were counted 14 days after sowing. Statistical analysis (Table 3) consisted in one-way ANOVA (with soil type as the factor) owing to different input parameters of seeds in particular varieties. All statistical procedures were performed using STATGRAPHICS Centurion XV (StatPoint 2007).

Based on the emergence results (Table 3), the varieties could be divided into two groups: sensitive or tolerant to different soil conditions. The varieties in the "sensitive" group showed the significantly highest emergence in Luvisol and the significantly lowest emergence in Cambisol. Due to different germination of varieties, differences between the two groups were investigated by one-way ANOVA on the level of relative emergence, when the number of germinated seeds was 100%. Differences between groups showed insignificantly different values of emergence in Chernozem in both groups. The "sensitive" group had significantly higher emergence in Luvisol and significantly lower in Cambisol. However, the "sensitive" and "tolerant" group of varieties did not show any significant differences in the evaluated seed parameters (Table 1).

The obtained results indicated that lucerne seed emergence could be influenced by the used soil. However, this effect was significant only for seeds of some lucerne varieties and some lucerne seeds need not reduce their emergence under less favourable soil conditions. Benabderrahim *et al.* (2011) also reported significant differences in seed emergence among 20 lucerne landraces from Tunisia. Nevertheless, the effect of variety could not be separated from the effect of seed lot in our experiment. Therefore the basic parameters of used seeds were compared between the "sensitive" and "tolerant" group. There were not detected any significant differences in germination or germinative energy between the two groups. This finding is in accordance with the results published by Wang *et al.* (1996), who reported that standard germination and germination index were not significantly correlated with seedling emergence. For seed emergence prediction, a vigour test based on seed conductivity was recommended (Wang *et al.* 1996).

High salinity significantly reduced seed emergence (Al Doss 2011), but no detrimental effect of salinity was detected in our experiments. Seed size expressed by WTS is generally accepted as a parameter which is positively related to higher seed emergence (e.g. Hakl *et al.* 2011b). Large seeds improved seedling emergence and survival in slightly and moderately saline media (Steppuhn *et al.* 2009) or at different sowing depth (Townsend 1992). Higher WTS can probably improve seed emergence in deteriorated soil conditions, however, the high number of used seeds and a lower range of WTS (0.37 g) in our experiment did result in any significant differences between the groups of varieties. Hrušková (1991) reported lower emergence of hard seeds, but in our experiments

Table 2. Description of sites and basic soil characteristic

Site	Červený Újezd	Suchdol	Vatín
Altitude (m a.s.l.)	405	281	540
Soil type	Haplic Luvisol	Haplic Chernozem	Haplic Cambisol
Particle size distribution	Clayey-loam	Clayey-loam	Loamy
Sand (0.05–2 mm, %)	22.0	16.4	48.0
Silt (0.002–0.05 mm, %)	55.6	54.9	39.5
Clay (< 0.002 mm, %)	22.4	28.7	12.4
Salinity (μS/cm)	16.1	19.7	46.5
pH (H_2O)	7.7	7.9	5.0
pH (KCl)	6.9	7.1	4.4

Table 3. The seed emergence in evaluated soils in sensitive (SEN; $P < 0.05$) and tolerant (TOL; $P > 0.05$) varieties

Group	Variety	G (%)	Chernozem		Luvisol		Cambisol		*P*
			abs.	rel.%	abs.	rel.%	abs.	rel.%	
SEN	Europe	74	57^{ab}	77	63^{a}	85	46^{b}	62	0.023
	Jarka	91	74^{ab}	81	85^{a}	93	67^{b}	74	0.000
	Litava	80	70^{ab}	88	77^{a}	96	59^{b}	74	0.042
	Magda	84	76^{a}	90	73^{ab}	87	61^{b}	73	0.023
	Oslava	92	74^{a}	80	84^{b}	91	75^{ab}	82	0.034
	Pálava	94	69^{a}	73	84^{b}	89	66^{a}	70	0.004
	Tereza	77	53^{a}	70	71^{b}	93	52^{a}	68	0.000
TOL	Holyna	71	46	65	51	72	48	68	0.325
	Jitka	84	71	85	69	82	74	88	0.734
	Kamila	75	66	88	60	80	55	73	0.083
	Morava	87	75	86	78	90	75	86	0.671
	Niva	89	78	88	79	89	71	80	0.131
	Vlasta	86	67	78	60	70	64	74	0.414
	Zuzana	80	66	83	67	84	68	85	0.777
SEN	mean	$n = 28$		80^{b}		91^{a}		72^{c}	0.000
TOL	mean	$n = 28$		82		81		79	0.813
P				0.497		0.000		0.002	

G – germination, abs. – number of seedlings from 100 seeds, rel.% – ratio of seedlings from germinated seeds; means in rows followed by the same letter are not significantly different from each other (Tukey HSD; $P = 0.05$); *P* in the last row characterizes differences between variety groups

the content of hard seeds was not significantly different between the groups of varieties, which could be connected with a lower occurrence of hard seeds – up to 13%.

It should be noted that seed emergence in the field is also related to actual field conditions such as temperature (Sakanoue 2010) or soil moisture (Wang *et al.* 1996). A detrimental effect of the higher content of clay was indicated by significantly lower emergence in Chernozem in comparison with Luvisol at the same pH value, but at higher clay content. Obviously, emergence under optimal moisture conditions and depth of sowing in the greenhouse is higher in comparison with field conditions where average emergence usually ranges between 30 and 60% (Hrušková 1991).

It is to assume that unfavourable soil conditions reduced seed emergence of lucerne, but the results support an idea that emergence could probably be improved by the selection of an appropriate variety. There still exists a possibility that higher emergence was connected with other properties of seeds not evaluated in this study. In this case, searching for these seed parameters could be useful for the selection of a suitable lot of lucerne seeds which could be used in deteriorated soil conditions.

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