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Stimulation sorghum seed leading to enlargement of optimum conditions during germination and emergence

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ABSTRACT

The ways to improve the vitality of sorghum seed after treatment with Lexin and M-Sunagreen were tested in laboratory conditions. These methods of seed stimulation were also tested in field conditions. All experiments were carried out in 2011–2013. Positive results after using the presented formulations for testing of germination were observed not only in laboratory conditions but also in field experiments. Seeds stimulated by Lexin reached statistically higher germination (95%) compared to control (91.5%) with the shortest medium time of germination (3.5 days) versus control seeds (4.3 days). Higher, faster and smoother germination of stimulated seeds resulted in higher average number of plants per m^2 (about 2.1 plants/1 m^2 in Lexin compared to control seeds) and thereby contributed to higher average yields up to two tons of dry matter per hectare.

Keywords: seed treatment; yield; auxin; emergence; soil temperature

The temperature during germination and sprouting is one of the limiting factors influencing the growth of sorghum plantations in Central Europe conditions. Due to lower demand for moisture during vegetation and high yields of the aboveground biomass, sorghum is one of the few crops that can be successfully grown in drier conditions as a possible alternative to silage corn for feed purposes and for biogas production (Pazderů et al. 2014).

Initial conditions during setting up of vegetation are very important for successful cultivation of sorghum. The first important factor for optimum germination and sprouting of seeds is enough moisture, which – due to the sowing-depth of about 3 cm – is largely dependent on sufficient totals rainfall shortly after sowing. Enough moisture and its efficient use will be limiting factor for growing most crops in our conditions in future. As Tolk et al. (2013) stated, water stress can reduce the biomass yield up to 45%. The second no less important critical factor during germination and sprouting is soil temperature (Alvarado and Bradford 2002). Due to relatively high fluctuation of rainfall in spring and the impossibility to influencing that, producers are forced to seek possibilities for growing sorghum during thermally less favourable conditions but with enough moisture (Brar et al. 1992, Lobato et al. 2008). The use of sowing treatment of seeds to increase the resistance of commonly used commercial seeds is one possibility to eliminate negative temperature conditions (Pazdera 2002). Modifications of seeds mainly improve seed characteristics with an emphasis on achieving faster and uniform germination and emergence, while extending the environmental conditions in which seeds can germinate well (Esechie 1994). Phytohormones in the seeds participate in the control of germination and early growth stages of germinating plants. Auxins applied to seeds of root vegetables show positive results in the germination of plants (Procházka et al. 1998). Besides the environmental conditions, we must not forget the important significance of nitrogen abundance as a basic element in the cultivation of sorghum in field conditions, the absence of which can significantly reduce the formation of yield (Hao et al. 2014).

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MATERIAL AND METHODS

The germination of sorghum seeds treated for germination at different temperatures and different types of stimulation was observed in 2011–2013 in the laboratory at the Department of Crop Production, Czech University of Life Sciences (CULS). The obtained laboratory results were verified in the field trial which took place at the Research Station in Prague-Uhříněves.

The certified seed of sorghum cv. Goliath-Biomaas 133 was used from the Saatbau LINZ Czech Republic s.r.o., and cv. Zerberus from the KWS seed, s.r.o. In both cases, the produced seed was treated with the active ingredient Thiram at a dose of 1 kg/1 t of seeds.

Seeds were treated with preparations Lexin (acid indole-3-acetic acid) and M-Sunagreen (2-aminobenzoic acid and 2-hydroxybenzoic acid) as a solution, which was applied with a calibrated dispenser to the surface of seeds. Then, the seeds were mixed thoroughly in a homogenizer. Preparations dried up on the surface of seeds at a constant temperature of 20°C and at normal pressure. Volume of the pure product per 100 g of seeds was 9.6 μL of Lexin and 15 μL of M-Sunagreen. The total volume of the solution with water per 100 g of seeds was 1 mL. Obtained results were compared to control seeds, injected with 1 mL of pure water to 100 g of seeds.

Germination tests were established according to the ISTA methodology and were carried out on a pleated filter paper (FP method) at 60% water saturation in covered plastic boxes. Heat stress was simulated in climate box with temperatures of 12, 15, 18 and 21°C, protected from light for 21 days. Individual variants were always tested in four replications of 100 seeds. Germinated seeds (with roots greater than 3 mm) were counted at 24 h intervals. Germination (G), germination energy (GE) and the mean germination time (MGT) were determined.

Treated seed was tested in field conditions on experimental plots with an area of 12 m^2 each in 5 repetitions. The soil temperatures at the time of seeding were 12°C in all three years. 80 kg N/ha (UREA stabil) was applied before sowing. The machine used for sowing was Wintersteiger and the seed quantity used was 7 kg/ha (220 000 seeds/ha), the inter-line distance 25 cm and 50 cm with sowing depth of 3 cm. The plants were treated with BANVEL® 480 S at a dose of 1 L/ha, by using a hand sprayer. During the experiment field emergence (FE), emergence energy (EE) with a median germination (MGT) and total dry matter yield were determined.

Laboratory and field results were evaluated by an analysis of variance in the statistical program SAS 9.1 (SAS Institute Inc., Cary, USA). A more detailed assessment of the differences between means was performed using the honest significant difference (*HSD*) (Tukey's test).

RESULTS AND DISCUSSION

Germination tests conducted in 2011–2013 are summarized in Table 1; they show a positive influence of application of both preparations Lexin and M-Sunagreen on seed germination. Stimulation of seed with Lexin influenced both studied cultivars and at all investigated temperatures high germination (95%) and the shortest mean germination time (3.5 days) were observed compared to control. The achieved results correspond with the research and experiments of Procházka et al.

Table 1. Effect of preparations Lexin and M-Sunagreen on the germination of seed sorghum, the average of all grades and temperatures monitored

Treatment	Germination (%)	Mean germination time (days)	Germination energy (%)		
			2^{nd} day	3^{rd} day	5^{th} day
Lexin	95.0^a	3.5^a	32.3^a	49.8^a	76.4^a
M-Sunagreen	92.2^b	4.0^b	27.5^b	46.8^b	67.4^b
Control	91.5^b	4.3^c	27.2^b	44.8^c	67.2^b
LSD	1.1	0.01	1.5	1.8	1.4

Diameters with the same letters are not statistically significant. *LSD* – least significant difference

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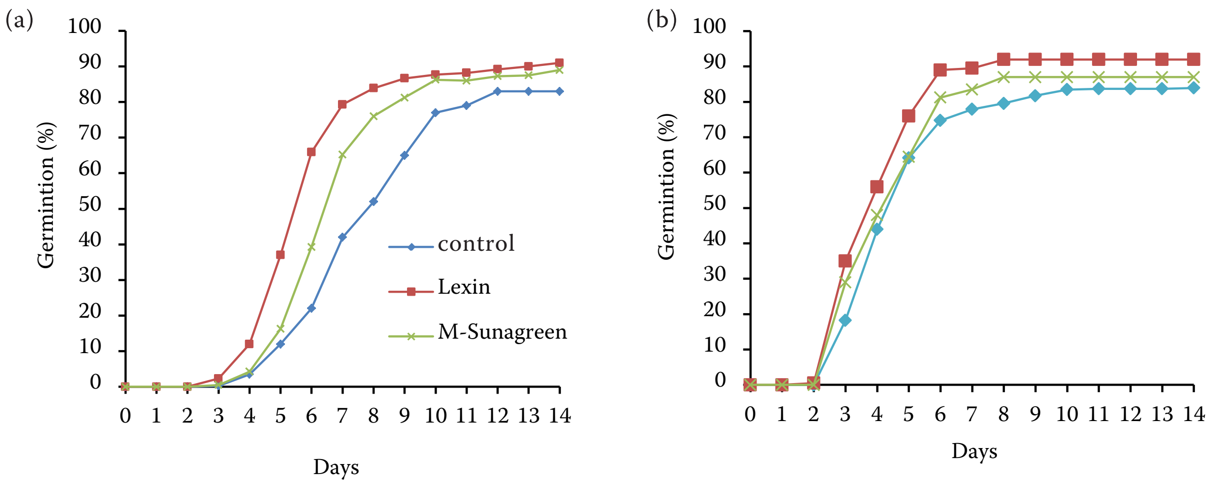

Figure 1. Sorghum seed germination at (a) 12°C and (b) 15°C

(2015), where the analogy use of the preparation Lexin to soybean seeds increased germination and field emergence, seed vigour and subsequently root weight. Conversely, untreated plants of both cultivars tested during all temperatures reached the lowest germination percentage (91.5%) and longest (4.3 days) mean time of germination. Stimulation of seed with M-Sunagreen had a statistically significantly positive effect on the mean germination time, but it had no statistically significant effect on germination energy and total germination.

Seeds treated with auxins M-Sunagreen and Lexin proved suitable measures to enhance the vigour of sorghum seeds, especially during germination and emergence at lower temperatures. The optimum temperature for germination of sorghum is above 20°C. Sorghum begins to germinate at the temperature of 12°C (Tóth 2014). Differences between the treatments increased with decreasing temperature during germination, where the highest differences were apparent at 15°C and 12°C (Figure 1). In case of temperatures of 18°C and 21°C, there were differences in the speed of germination between the modified seeds (Lexin) and untreated control of 1 day, while at a temperature of 12°C the germination speed amounted to five days, which corresponded with the results Krenchinski et al. (2015), who studied the germination rate of *Sorghum arundinaceum*. Noticeable decrease in speed of germination of sorghum seeds was during sprouting at low temperatures, which is consistent with the results obtained by Brant et al. (2011).

Modification of seed before sowing using Lexin and M-Sunagreen had a positive effect on the shortening of emergence time and increased emergence under field conditions. Although the weather in all three years was thermally normal to extremely warm, temperature of the soil at 3 cm depth was 12°C and emergence time after application of Lexin was in average of three years shortened by 3 days compared to control and field sprouting increased above 7% (Table 2). Also, application of the preparation M-Sunagreen had a statistically significant effect for the acceleration of field sprouting compared to control.

Table 2. Influence of seed treatment on the field sprouting of sorghum; average of 2011–2013

Treatment	Days	σ	Number of periods
Control	12.37[a]	0.223708	24
M-Sunagreen	10.29[b]	0.229043	24
Lexin	9.50[c]	0.170251	24

The same letters are not statistically significant

Table 3. Sprouting of sorghum seeds under field conditions in 2011–2013

Treatment	Sprouting (%)	σ	Number of periods
Lexin	96.44[a]	0.306730	24
M-Sunagreen	93.73[b]	0.349507	24
Control	89.57[c]	0.322294	24

The same letters are not statistically significant

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Table 4. Number of plants per 1 m^2 for each treatment

Treatment	Number of plants/1 m^2	σ	Number of periods
Lexin	25.5[a]	0.850857	24
M-Sunagreen	24.4[b]	0.922699	24
Control	23.4[c]	0.809766	24

The same letters are not statistically significant

Field results showed the efficacy of sorghum seed treatment by Lexin and M-Sunagreen. An important indicator for the effectiveness of the treatments is number of plants observed 30 days after sowing; it was statistically proven that seed treatment with Lexin reported the highest average number of plants 25.5 pcs/m^2 compared to untreated controls (23.4 pcs/1 m^2). The results correspond with the statement of Procházka et al. (2015), who observed that the application of Lexin on soybean seeds increased number of plants over the years 2012 to 2014 up to 23%. Treatment with M-Sunagreen had a statistically significant effect on a greater number of plants (24.4 pcs/1 m^2) per unit area relative to the untreated control seeds (Table 4).

The proposed sorghum seed treatment showed certain advantages during germination and sprouting during cooler conditions. It is a positive result, which was necessary to confirm when comparing the yield of green mass and dry matter. These are the parameters that mainly interest growers and largely guarantee the suitability of cultivation of sorghum in the Czech Republic. Yield formation is understood as a dynamic process that is influenced by weather, dynamics of the release of nutrients from the soil, harmful agents and agrotechnical interventions. It also depends on biological material (cultivars and hybrids). High quality seed is essential for a high potential return of sorghum. The high quality seed is able to germinate in local climatic growing conditions as only high field sprouting provides essential prerequisite for high returns (Lobato et al. 2008). The proposed measures did not have a significant effect on the dry matter content, i.e., the sorghum matured evenly with mean values of 33.0% at control treatment to 33.35% at application Lexin (Table 5). A significantly higher number of nodes detected with Lexin (13.89 pcs compared to the control treatment 12.94 pcs) was an interesting result. Total dry matter yield was statistically significantly influenced with applications of Lexin (11.60 t/ha) and M-Sunagreen (11.41 t/ha) compared to control (9.95 t/ha). The application of auxins has a positive effect for growth rate of plant cells, also showed by Vanneste and Friml (2009). Total dose of nitrogen – 80 kg N/ha was applied in experiments which corresponds with the results of Oprea et al. (2016), who reported 90 kg N/ha as the optimal dose for sorghum to achieve high yields of the above-ground biomass.

Weather can be of great importance in the individual years, the abnormality can affect the yields of dry matter. As to temperature, the year 2012 was evaluated as normal (+ 1.45°C above normal), 2011 was assessed as hot (+ 1.6°C) and 2013 as extremely hot (+ 4.6°C above normal). Total precipitation for the years corresponds to the long-term average in the area (Kožnarová and Klabzuba 2002).

The results have been verified in fair conditions by selected growers in the Prague East district, who are considering the inclusion of sorghum in their permanent crop rotations for the future to ensure sufficient biomass for dairy cows and biogas plants.

Table 5. Effect of seed treatments on dry matter yield in individual years

Treatment	2011		2012		2013		Average 2011–2013			
	dry content (%)	dry matter yield (t/ha)	dry content (%)	dry matter yield (t/ha)	dry content (%)	dry matter yield (t/ha)	dry content (%)	σ	dry matter yield (t/ha)	σ
Lexin	33.35	10.54	30.32	12.25	29.21	12.07	30.96[a]	0.3432	11.60[a]	0.3118
M-Sunagreen	33.2	9.98	30.05	12.48	28.03	11.78	30.35[a]	0.3444	11.41[a]	0.2573
Control	33	8.85	30.62	10.97	29.4	9.32	31.00[a]	0.3495	9.71[b]	0.2525

The same letters are not statistically significant

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