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The influence of pre-sowing seed treatment by biologically active compounds on soybean seed quality and yield

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ABSTRACT

The aim of the experiment was to improve seed quality of harvested soybean seed by pre-sowing seed treatment with biologically active compounds Lignohumate B (mixture of humic and fulvic acids), Lexin (mixture of humic and fulvic acids enriched by auxins), brassinosteroid (synthetic analogue of natural 24 epibrassinolide) and so-called complete seed treatment (mixture of saturated solution of sucrose, Lexin, Maxim XL 035 FS fungicide of Syngenta and adjuvant on the base of pinolene). Four-year experiments proved positive influence of all treatments to seed parameters (laboratory germination, seed vigour (AA test), field emergence and thousand seed weight).

Keywords: *Glycine max*; seed value; vigor; seed germination; biologically active compounds

Setting up of optimal and covering crop stand is a precondition for high yields of soybean seed. For this reason, the quality, thus vigorous seed, is understood as a basic factor, which can be achieved on good crop stands. Main seed parameter tested by ISTA rules is laboratory germination (Egli and TeKrony 1995, Procházka et al. 2015a). It explains that maximum performance of seeds in optimal conditions from the farmers' view may be a different concept, because it requires the seed to uniformly and quickly germinate and emerge. From that point of view the most important is good seed performance in adverse conditions, i.e. seed vigour (Pazderů 2009). According to Egli and TeKrony (1995), Chaloupský et al. (2013) and Procházka et al. (2015b), it is therefore important to monitor also the biological value of the seed. It reflects genetic traits of the cultivar and environmental conditions and agriculture engineering, in which the seed was produced.

One of the effective agrotechnical measures used in establishing of seed soybean crop stands is seed treatment by biologically active substances (Taylor and Harman 1990). For biologically active substances are considered different growth regulators, enzymes, substances associated with plant bioenergy or photosynthetic pigments forming protein complexes which are involved in energy conversion of electromagnetic radiation to energy of chemical bonds (Dřímalová 2005). A number of biologically active substances showed a beneficial effect on seed germination and subsequent plant growth of soybean. During vegetation, the treated plants are better to cope with stress, which often comes in the form of particular deficiency of moisture or temperature extremes (Egli et al. 2005). According to some authors, biologically active compounds based on a blend of synthetic auxins, humic and fulvic acids very favourably influenced germination and subsequent plant growth. Substantially similar efficacy was demonstrated in many experiments using synthetic analogues of some brassinosteroids, which, among other things, positively interact with auxin (Kohout 2001, Chen et al. 2004, Anuradha and Rao 2007).

To test the vigour of soybean seed there is only one internationally recognized test – the accelerated ageing test (AA test). It is the only method for soya that has no problem with repeatability and total objectivity (Woltz and TeKrony 2001, TeKrony 2003). AA test exposes seeds to short periods of high temperature and humidity. During the test,

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the seeds absorb moisture from the environment and increased water content, together with high temperature, then accelerates the ageing of the seeds. Seeds with high vigour are more resistant to these stress conditions and age more slowly than seeds with low vigour. Accelerated ageing test is somewhat durability test for soya; it applies both to the field emergence and to predict whether a given seed can be stored to the next year (TeKrony 1995, 2003).

MATERIAL AND METHODS

The aim of the experiment was to study the influence of seed treatment by biological active compounds to seed quality of harvested seeds. Four ways of treatment (Lignohumate B, Lexin, brassinosteroid and Complex treatment) were tested against non-treated control.

Lignohumate B is a mixture of humic acids produced in process of organic transformation from waste wood with the ratio of humic and fulvic acids 1:1 (Amagro company).

Lexin is concentrated solution of humic acids, fulvic acids and auxins supporting plant cell division and elongation. An improving influence on creation and growth of roots and an increase of yield were observed (Lexicon company).

Brassinosteroids are relatively new group of steroid phytohormones from terpenic family. They were found in oil seed rape (*Brassica napus* L.) pollen in the USA in 1970 (Nováková et al. 2014). Substance No. 4154 (brassinosteroid), synthetic analogue of natural 24 – epibrassinolide ((2α,3α,17β-trihydroxy-5α-androstan-6-on, Vlašánková et al. 2009), was used in the experiment.

Table 1. Scheme of pre-sowing seed treatment

Treatment	Dose per 20 kg of seed
Lignohumate B	25.7 mL, water
Lexin	6.5 mL, water
Brassinosteroid	2.2 mL substance 4154, water
Complex treatment	saturated solution of saccharose 6.5 mL Lexin 10 mL Agrovital 20 mL Maxim XL 035 FS
Untreated control	200 mL water

Total volume of all solutions was 200 mL

Complex treatment used a mixture of saturated solution of saccharose, Lexin, fungicide Maxim XL 035 FS and surfactant agent pinolene (Agrovital).

Field experiments were conducted in the years 2012–2015 with middle early cv. Merlin (000+). In order to respect the unity of methodology for seed treatment, seeds were treated directly before sowing in all years, according to the scheme in Table 1.

Together with active compounds, seeds were inoculated by Nitrazon+ (mixture of peat soil with bacteria *Rhizobium* sp., *Azotobacter* sp. and *Bacillus megatherium*). Inoculated seeds were used as untreated control. Sowing rate of all experimental variants was 68 seeds per square meter.

The experiment was designed as long plots, with three replications (1000 m^2 each) at the Studeněves area, Czech Republic.

The pre-crops of soybean were spring barley, winter wheat, spring barley and winter wheat, in this order from 2012 to 2015. For all experimental treatments, the same growing technology was used:

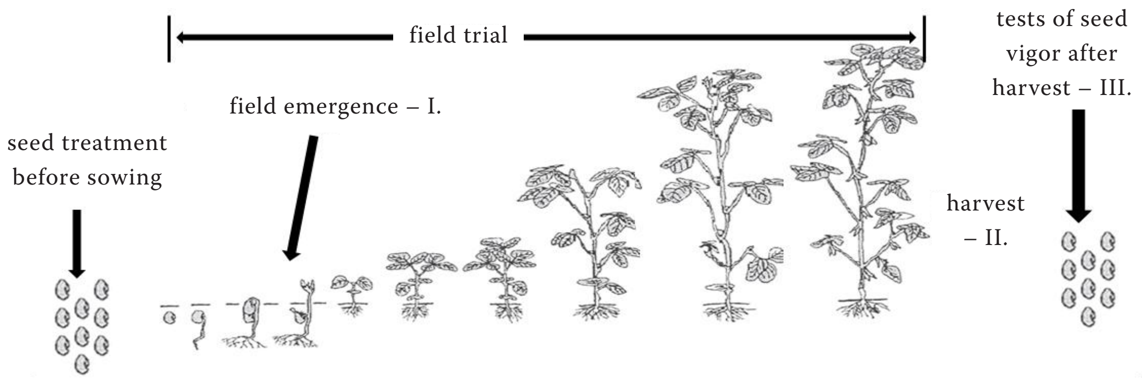

Figure 1. Scheme of pilot field trial evaluation

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Table 2. Characterization of experimental location

Locality	GPS coordinates	Year	Altitude a.s.l. (m)	Average annual temperature (°C)	Annual sum of precipitation (mm)	Soil type	Soil texture
Studeněves	50°13'50''N, 14°2'54''E	2012	302	8.70	653	arenic cambisol	loam
		2013	306	8.20	684		
		2014	314	9.80	587		
		2015	325	9.80	491		

Stubble breaking with disc harrow directly after pre-crop harvest;
– chisel ploughing to 30 cm;
– NPK 15 fertilization (dose 200 kg/ha) before sowing in spring;
– pre-sowing tillage – 2 × cultivator, depth 6 cm;
– seed treatment and sowing;
– pre-emergence herbicide treatment;
– harvest.

Evaluated parameters:
– Field emergence of seed crop stand;
– yield of seed crop stand;
– biological value of seed.

The effect of seed treatment to the biological value of the seed produced was tested for three basic seed parameters: laboratory germination, seed vigour (AA test) and thousand seed weight (TSW) of harvested seed. These parameters were investigated always about one month after harvest of seed stands. The AA test was conducted in accordance with the methodology for accelerated ageing test ISTA. Immediately after the accelerated ageing, test followed germination test, as well as non-aged seeds.

The results of the field trial were processed by General Linear Model (GLM ANOVA) using SAS statistical program (version 9.3, Carry, USA). Differences between mean values were evaluated by Tukey's *HSD* (honestly significant difference) test at the level of significance $P = 0.05$.

RESULTS AND DISCUSSION

According to Egli and TeKrony (1995) and Procházka et al. (2015a) fully wired and homogeneous seed stand is one of the basic assumptions of quality seed production. Figure 2 shows that the seed treatment by biologically active substances before sowing leads to higher field emergence, which is an important precondition for high-yielding crop stand.

Figure 3 demonstrates the average yield of individual treatments in the years 2012–2015. It should be noted that soybean yields vary between years, which is a common phenomenon in legumes. For that reason, the results present four year average values.

It is evident that if the seed treatment by biologically active agents allow for more rapid achievement of a compact, vital and thus competitively better stand, those plants could provide high yield. The highest yields were harvested in variants whose

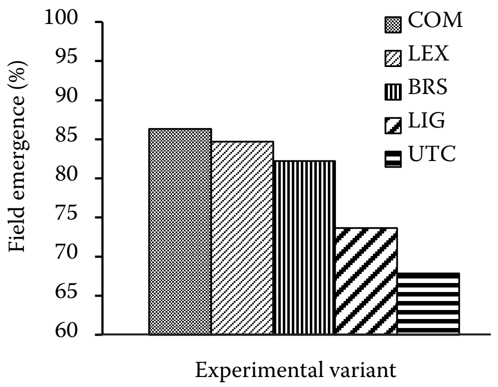

Figure 2. Field emergence of tested variants (average of the years 2012–2015). COM – complex treatment; LEX – Lexin; BRS – brassinosteroids; LIG – lignohumate; UTC – untreated control

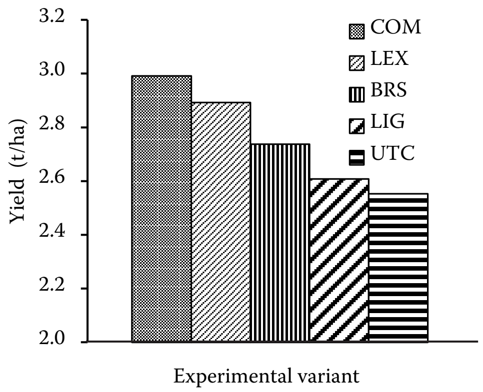

Figure 3. Seed yield of tested variants (average of the years 2012–2015). COM – complex treatment; LEX – Lexin; BRS – brassinosteroids; LIG – lignohumate; UTC – untreated control

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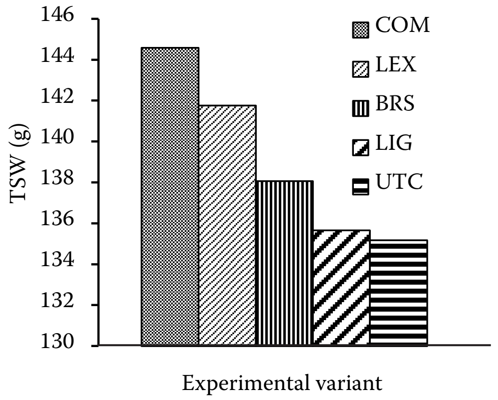

Figure 4. Thousand seed weight (TSW) of tested variants (average of the years 2012–2015). COM – complex treatment; LEX – Lexin; BRS – brassinosteroids; LIG – lignohumate; UTC – untreated control

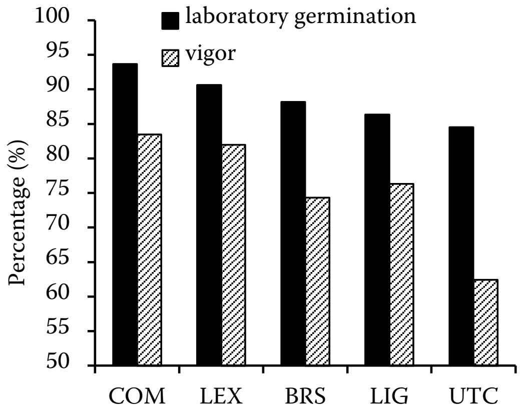

Figure 5. Laboratory germination and seed vigour (seed germination after the AA test) of tested variants (average of the years 2012–2015). COM – complex treatment; LEX – Lexin; BRS – brassinosteroids; LIG – lignohumate; UTC – untreated control

seed was treated by Complex treatment (2.99 t/ha) and by the product Lexin (2.89 t/ha). Lexin composition is, as already mentioned, a mixture of humic acids, fulvic acids and auxin and precise synergy of these components supports mainly rapid division and growth of cells tissues and formation of vascular bundles in the initial growth stages and the growth rate and formation of the plant as a whole. Štranc et al. (2008) demonstrates the positive effect of Lexin and brassinosteroids in their experiments. A positive effect of auxin on division and growth of plant cells was also mentioned by Procházka et al. (2015a). Brassinosteroids often act in synergy with auxins (particularly IAA), which is the cause of positive results of plants treated by brassinosteroid (synthetic analogue of the natural 24-epibrassinolide). Hradecká et al. (2009) also show similar effects of brassinosteroids and auxins.

One of the conditions to achieve high seed vigour is the content of a sufficient amount of storage compounds (Pazderů 2009, Procházka et al. 2015a,b). Main ingredients in soybean are proteins and fats, which in sufficient quantities play an important role in seed germination and seedling emergence. Increased seed weight (thus higher thousand seed weight) is therefore a guarantee that the seeds have a sufficient amount of storage compounds, and thus higher vigour. Similar conclusions were reported by Côme and Corineau (1993). Figure 4 and Table 3 show that the seeds from plants that were treated particularly by products containing auxin (Lexin and Complex treatment) before sow-

Table 3. Results of statistic evaluation (average of the years 2012–2015)

Parameter/ treatment	Field emergence (%)	Seed yield (t/ha)	TSW (g)	Laboratory germination	Seed vigor*
COM	86.33[a]	2.99[a]	144.58[a]	93.68[a]	83.50[a]
LEX	84.73[a]	2.89[b]	141.76[b]	90.64[ab]	81.98[a]
BRS	82.22[b]	2.74[c]	138.07[c]	88.19[bc]	74.35[b]
LIG	73.65[c]	2.61[d]	135.67[d]	86.36[cd]	76.33[b]
UTC	67.88[d]	2.55[e]	135.18[d]	84.51[d]	62.45[c]
HSD	1.7691	0.0545	1.5124	3.5723	4.2734
N	12	12	12	12	12

N – number of replications; *HSD* – honestly significant difference; UTC – untreated control; LIG – lignohumate B; BRS – brassinosteroid; LEX – lexin; COM – complex treatment. Means with the same letters are not statistically significant. *Seed vigour – laboratory germination after AA test; TSW – thousand seed weight

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ing achieved significantly greater TSW compared to seeds harvested from untreated plants.

From Figure 5 it is apparent that the seed harvested from seed stands established using biologically active substances showed higher laboratory germination than seed from untreated control. The obtained results show the highest germination in case of COM and LEX treatments. The seed of these treatments gave favourable (statistically significant) results in terms of vigour, tested via the AA test. During the vegetation, these crop stands coped better with stress in the form of drought or high or low temperatures to ensure the formation of seeds with higher biological value, which corresponds with the results of Procházka et al. (2013). The fact that it is necessary to positively influence the biological value of seeds already during its production was pointed out by Egli and TeKrony (1995).

REFERENCES

Anuradha S., Rao S.S.R. (2007): The effect of brassinosteroids on radish (*Raphanus sativus* L.) seedlings growing under cadmium stress. Plant, Soil and Environment, 53: 465–472.

Dřímalová D. (2005): Growth regulators in algae. Czech Phycology, 5: 101–112. (In Czech)

Egli D.B., TeKrony D.M. (1995): Soybean seed germination, vigor and field emergence. Seed Science and Technology, 23: 595–607.

Egli D.B., TeKrony D.M., Heitholt J.J., Rupe J. (2005): Air temperature during seed filling and soybean seed germination and vigor. Crop Science, 45: 1329–1335.

Côme D., Corbineau F. (1993): Quatrième rencontre internationale sur les semences. In: Proceedings of the International Workshop on Seeds, Angers, ASFIS.

Hradecká D., Urban J., Kohout L., Pulkrábek J., Hnilička R. (2009): Utilization of brassinosteroids to stress control during growth and yield formation of sugar beet. Sugar and Sugar Beet Journal, 125: 271–273. (In Czech)

Chaloupský R., Honsová H., Capouchová I., Konvalina P., Stehno Z. (2013): Seed germination and vigor of spring cereal species and varieties. In: Proceedings Seed and Seedlings XI, Prague, CULS, 79–82.

Chen Y., Clapp C.E., Magen H. (2004): Mechanisms of plant growth stimulation by humic substances: The role of organo-iron complexes. Soil Science and Plant Nutrition, 50: 1089–1095.

Kohout L. (2001): Brassinosteroids. Chemické listy, 95: 583. (In Czech)

Nováková O., Kuneš I., Gallo J., Baláš M. (2014): Effects of brassinosteroids on prosperity of Scots pine seedlings. Journal of Forest Science, 60: 388–393.

Pazderů K. (2009): Importance of germination energy for seed quality evaluation. In: Proceedings of the Seed and Seedlings IX, CULS, Prague, 56–60.

Procházka P., Štranc P., Pazderů K., Štranc J., Jedličková M. (2015a): The possibilities of increasing the production abilities of soya vegetation by seed treatment with biologically active compounds. Plant, Soil and Environment, 61: 279–284.

Procházka P., Štranc P., Kupka I., Štranc J., Pazderů K. (2015b): Forest seed treatment with brassinosteroids to increase their germination under stress conditions. Journal of Forest Science, 61: 291–296.

Štranc P., Bečka D., Štranc J., Hradecká D., Štranc D. (2008): Possibilities of Brassinosteroids and Lexin use in soybean. In: Proceedings of the 43rd Croatian and 3rd International Symposium on Agriculture, Opatija, 614–618.

Taylor A.G., Harman G.E. (1990): Concepts and technologies of selected seed treatments. Annual Review of Phytopathology, 28: 321–339.

TeKrony D.M. (1995): Accelarated ageing test. In: Van de Venter H.A. (ed.): ISTA Vigour Test Seminar. Copenhagen, ISTA, 53–72.

Tekrony D.M. (2003): Precision is an essential component in seed vigour testing. Seed Science and Technology, 31: 435–447.

Vlašánková E., Kohout L., Klemš M., Eder J., Reinöhl V., Hradilík J. (2009): Evaluation of biological activity of new synthetic brassinolide analogs. Acta Physiologiae Plantarum, 31: 987–993.

Woltz J.M., TeKrony D.M. (2001): Accelerated aging test for corn seed. Seed Technology, 23: 21–34.

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