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Effects of biologically active substances used in soybean seed treatment on oil, protein and fibre content of harvested seeds

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ABSTRACT

In 4-year trials, soybean seeds were treated with biologically active substances: Lignohumate B (a mixture of humic acids and fulvic acids), Lexin (a mixture of humic acids and fulvic acids enriched with auxins), brassinosteroid (a synthetic analog of natural epibrassinolide 24) and so-called "Complex seed treatment" (a mixture of a saturated solution of sucrose, Lexin, the fungicide Maxim XL 035 FS and adjuvant on the base of pinolene). After harvesting soybean seeds from the individual variants, they were analyzed for oil, protein and fibre contents. The results show that the most effective method was "Complex seed treatment" which, compared to the untreated variant, significantly increased not only the yield but also the oil content of the seeds.

Indexing terms/Keywords

Glycine max, fibre, production, protein, oil, seed treatment.

Academic Discipline And Sub-Disciplines

Agriculture,

SUBJECT CLASSIFICATION

crop production

TYPE (METHOD/APPROACH)

Field experiment

INTRODUCTION

Soy beans are one of the world's leading protein components in compound feeds. For humans, soy is also important as an oil source, because soy is the second most important oilseed crop in oil palm. It contains a significant amount of omega 6 and omega 3 fatty acids, which are optimal in dietary terms. Compared to rapeseed oil, soybean oil does not contain erucic acid, which is very positive for human and animal health (Mousavi-Avval et al., 2011; Ramedani et al., 2011). One way to increase the production potential of soybeans and thus the production of quality soybean oil is to prepare the biologically active seed prior to its sowing (Procházka et al., 2015). Seed treatment is a biological, chemical and physical (mechanical) process used to mitigate the negative effects of various external or internal influences. It improves its germination and vigor and thus promotes the formation of a healthy plant with increased production potential (Khanzada et al., 2002; Egli et al., 2005). The process of seed treatment can be combined with the inoculation of legumes. We can therefore say that seed improvement is one of the very cheap and highly effective methods of plant protection and stimulation of growth (Procházka et al., 2016).

Various growth regulators, enzymes, substances associated with plant bioenergy or even photosynthetic pigments forming protein complexes that participate in the conversion of energy of electromagnetic radiation into energy of chemical bonds can be considered as biologically active substances (Dřímalová, 2005). A number of biologically active substances also have a beneficial effect on seed germination and subsequent growth of soy bean plants. According to some authors, biologically active substances based on a mixture of synthetic auxins, humic acids and fulvic acids have been very beneficial. Significantly similar performance has been shown in many experiments using synthetic analogs of some brassinosteroids which, among other things, positively interact with auxins. For example, gibberellins or carbohydrates can, among other things, be included amongst the biologically active substances with antistress effects that act primarily on the cellular level (Kohout, 2001; Chen et al., 2004; Anuradha et al., 2007).

MATERIAL AND METHODS

The experiment was established to determine the effect of soybean seed treatment on biologically active substances on the formation of yielding elements, the yield and the qualitative composition of the produced seeds (oiliness, protein content and amount of fibre). The following biologically active substances were used in the experiment: **Lignohumate B is** mixture of humic acids produced in process of organic transformation from waste wood with ratio of humic and fulvic acids 1:1 (Procházka et al., 2015). Lexin is concentrated solution of humic acids, fulvic acids and auxins supporting plant cell division and elongation. Improving influence to creation and growth of roots and increase of yield was observed (Procházka et al., 2016).

Brassinosteroids are relatively new group of steroid phytohormones from terpenic family. There 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), was used in the experiment.

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

Field trials were carried out during the growing season from 2012 to 2015 with a very early soybean variety Merlin (000+). In order to maintain the uniformity of the methodology, we treated variants each time immediately prior to sowing, according to the scheme shown in Table 1. We determined the sowing rate on the recommendation of a seed company that was 68 seeds per square meter for the Merlin variety. In all cases (in all variants), the seed was inoculated with Nitrazon+.

Table 1. Scheme of pre-sowing seed treatment

Treatment	Dose per 20 kg of seed
Lignohumatet B (LIG)	25.7 ml, water
Lexin (LEX)	6.5 ml, water
Brassinosteroid (BRS)	2.2 ml substance 4154, water
"Complex treatment" (COM)	saturated solution of saccharose
	6.5 ml Lexin
	10 ml Agrovital
	20 ml Maxim XL 035 FS
Untreated control (UTC)	200 ml water

- total volume of all solutions was 200 ml

Experiment was designed as long plots, with three replications (1000 m^2 each) at Studeněves area, Czech Republic. Weather details of experimental years and locality are presented in Table 2.

Table 2. Characterization of experimental location

Locality	GPS coordinates	year	a.s.l.[1]	°C[2]	mm[3]	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	arenic cambisol	loam
		2014	314	9.80	587	arenic cambisol	loam
		2015	325	9.80	491	arenic cambisol	loam

[1] – altitude above see levels (m); [2] – average annual temperature; [3] – annual sum of precipitation

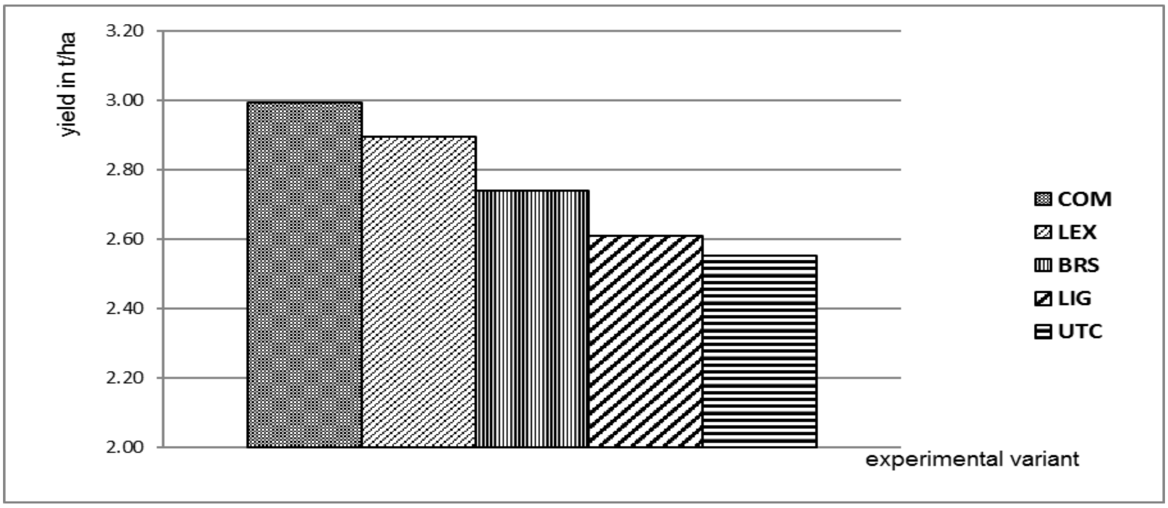
The pre-crops of soybean were spring barley, winter wheat, spring barley and winter wheat, in order from 2012–2015. For all experimental variants the same growing technology has been used: 1) stubble breaking with disc harrow directly after pre-crop harvest, 2) chisel plowing to 30 cm, 3) NPK 15 fertilizing (dose 200 kg ha-1) before sowing on spring, 40 pre-sowing tillage – 2x cultivator on depth 6 cm, 5) seed treatment and sowing, 6) pre-emergent herbicide treatment and 7) harvest.

After the harvesting of the soybean, the seeds were analyzed for oil, protein and fibre contents using a NIR spectrophotometer (OmegAnalyzer G Bruins Instruments).

The results of the field trial were processed by General Linear Model (GLM ANOVA) using statistical program SAS, version 9.4 (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

The results show that soybean seed treatment with biologically active substances has increased its yield (Fig. 1).



COM – complex treatment, LEX – Lexin, BRS – Brassinosteroids, LIG – Lignohumate, UTC – untreated control

Figure 1. Average yields in soybean seeds by variants (2012–2015)

The highest average seed yield was given by the variant COM, namely 3.29 t ha-1. Similar results were achieved by the LEX variant (3.18 t ha-1). All difference between variants were significant against control (Table 3).

Table 3. Results of statistic evaluation (average 2012-2015)

The parameter monitored	COM	LEX	BRS	LIG	UTC	HSD	N
Yield of seeds	2.99	2.89	2.74	2.61	2.55	0.0545	12
	a	b	c	d	e		
Oil content	19.09	19.03	19.08	18.60	18.74	0.2413	12
	a	a	a	b	b		
Protein in seed	33.35	33.01	32.49	33.83	33.44	0.6850	12
	ab	bc	c	a	ab		
Fibre content	4.95	4.93	4.96	4.90	4.85	0.0543	12
	ab	ab	a	bc	c		

Note. COM – “complex treatment”, LEX – Lexin, BRS – brassinosteroid, LIG – Lignohumate B, UTC – untreated control, HSD – honestly significant difference, N – number of repetitions; means with the same letters are not statistically significant. Lexin, as mentioned above, is a mixture of humic acids, fulvic acids and auxins, and the synergy of these components, especially in the early growth phases, promotes faster division and growth of cells, tissues and vascular bundles, and thus the growth and formation of the plant as a whole. The positive effect of Lexin and brassinosteroids was also shown by experiments by Štranc et al. (2008) or Adamcik et al (2016). The positive influence of auxins on the division and growth of plant cells are also mentioned by Prochazka et al. (2015). Brassinosteroids often act in synergy with auxins (especially IAAs), which is also the cause of the positive results of the variant that was treated with brassinosteroid (a synthetic analog of natural 24-epibrassinolide). The similar effect of brassinosteroids and auxins, which we have found, is also reported Gomeset al. (2011) and others.

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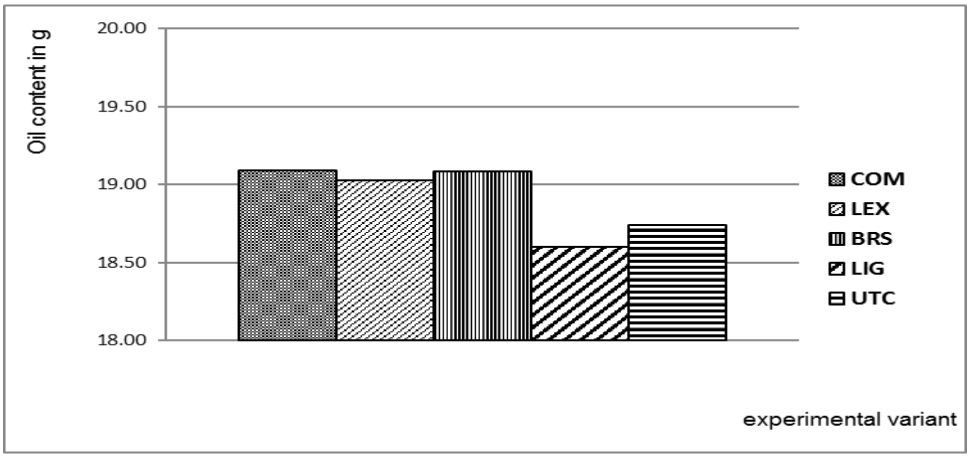
Figure 2 shows the oiliness of the seeds of each variant. The results show that soy seed treatment with biologically active substances (containing especially phytohormones) significantly increased the oil content of the produced seeds. The highest average oil content in the seeds was provided by the variant "Complex treatment" (19.09%). Very similar results were achieved by the variants with brassinosteroid (19.08%) and Lexin (19.03%), all significantly different from untreated control (Table 3).



COM – complex treatment, LEX – Lexin, BRS – Brassinosteroids, LIG – Lignohumate, UTC – untreated control

Figure 2. Oil content in soybean seeds by variants (average 2012–2015)

From the economic point of view, it is very important that the soybean seed treated by COM variant, compared to the untreated control, contributed to 19.4% increase in oil production per hectare (Figure 3). In absolute terms, this means an increase in oil production of 92.7 kg^{-1} ha, thus increasing its sales by 75.2 EUR per hectare at current prices (Rotterdam, May 2017). In the case of Lexin, oil production increased by 14.2% compared to untreated control and thus an economic contribution of 53.7 EUR ha^{-1}. Also treatment with brassinosteroid appears to be economically efficient as oil production increased by about 10% (brassinosteroid is not yet available in Czech domestic market). For the sake of completeness, it should be noted that the approximate price of Lexin for soya bean seed treatment is 2.1 EUR ha^{-1} and in the case of "Complex treatment" 8.6 EUR ha^{-1}. The positive effect of Lexin and brassinosteroid on oil content also suggests the results of Štranc et al. (2008). Very good results of utilization of brassinosteroids for the yield formation and production for man of usable substances were confirmed by Hradecká et al. (2009) in experiment with sugar beet.

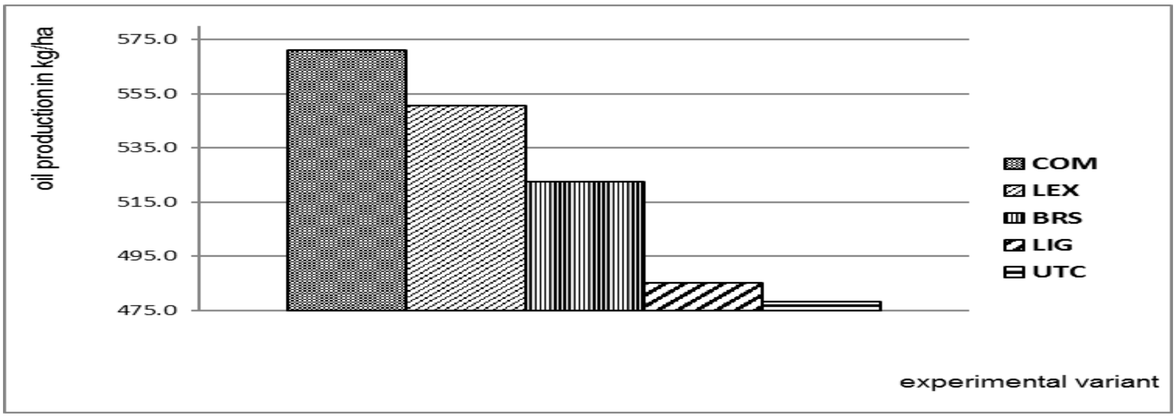


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Figure 3. Oil production per hectare by variants (average 2012–2015)

Soybean oil production is usually linked to protein content, as exemplified, for example, Panthee et al. (2005) The established oiliness and protein content (Figures 2, 4) confirm the generally valid fact that the proportion of these substances in soybean is indirect (figures 3, 5). From the values of Figure 6 it is obvious that the seed treatment with biologically active substances slightly increased the fibre content of the harvested seeds (statistically significant to untreated control except LIG variant – Table 3).

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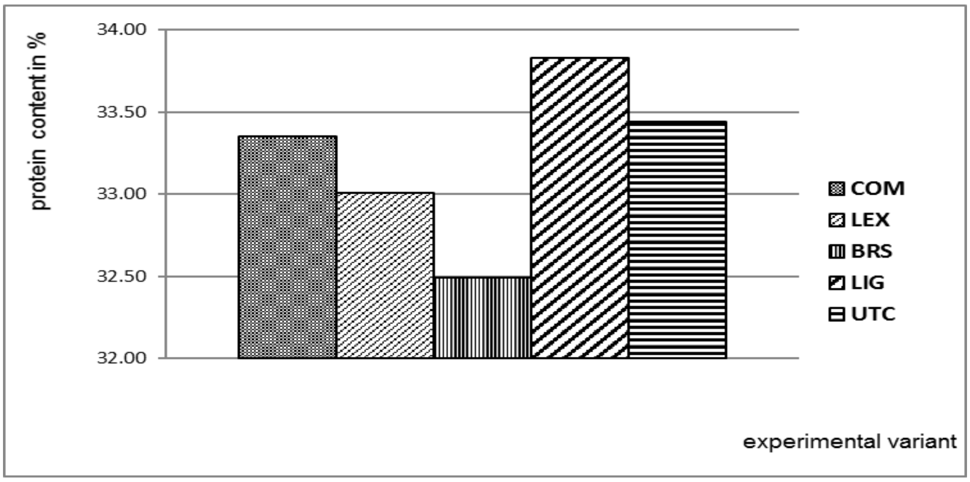
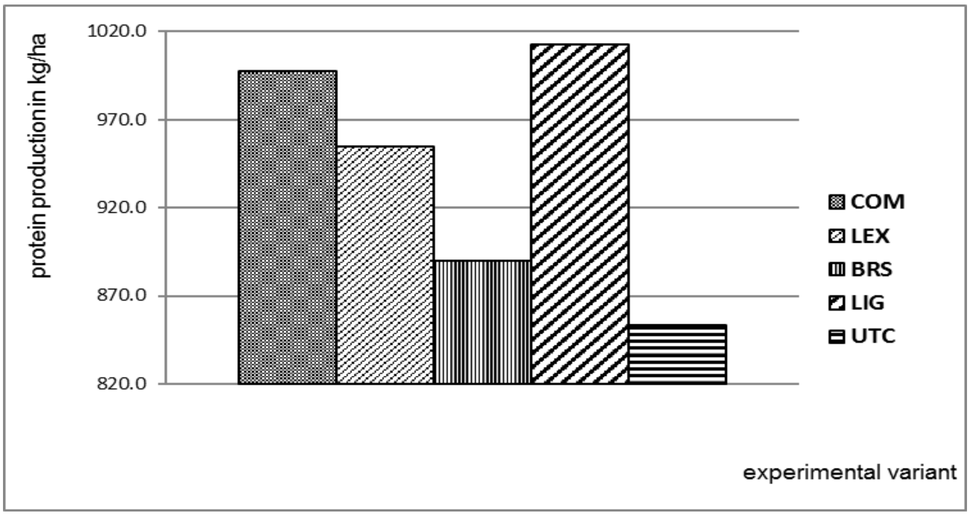


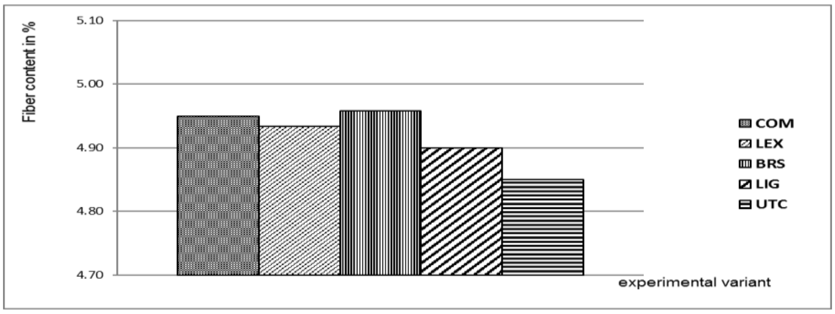
COM – complex treatment, LEX – Lexin, BRS – Brassinosteroids, LIG – Lignohumate, UTC – untreated control

Figure 4. Protein content in soybean seeds by variants (average 2012–2015)



COM – complex treatment, LEX – Lexin, BRS – Brassinosteroids, LIG – Lignohumate, UTC – untreated control

Figure 5. Protein production per hectare by variants (average 2012–2015)



COM – complex treatment, LEX – Lexin, BRS – Brassinosteroids, LIG – Lignohumate, UTC – untreated control

Figure 6. Fibre content in soybean seeds by variants (average 2012–2015)

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CONCLUSION

Soybean seed stained with biologically active substances promoted the establishment of a high-quality and vital crop stand, which provided a higher seed production with significantly higher oiliness. The highest treatment costs were spent on the "Complex treatment" option (EUR 8.6 per hectare). This variant provided not only the highest yield of seeds in all experimental years, but also their highest oiliness, thereby greatly compensating for the increased costs to seed treatment. From the results obtained, it is obvious that use of biologically active compounds for soy seed treatment ("Complex", as well as Lexin, or Brassinosteroid) is significant contribution to increase not only soybean seed yield but also soybean oil production.

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