doi: 10.17221/225/2015-PSE

The possibilities of increasing the production abilities of soya vegetation by seed treatment with biologically active compounds

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ABSTRACT

In three-years experiments soya seeds were treated with biologically active compounds: Lignohumate B (mixture of humic and fulvic acids), Lexin (mixture of humic and fulvic acids enriched by auxins), brassinosteroid (syntetic analogue of natural 24 epibrassinolide) and so-called complete seed treatment (mixture of saturated solution of sucrose, Lexin, fungicide Maxim XL 035FS and adjuvant on the base of pinolene Agrovital). During vegetation following characteristics were observed: field germination, density of vegetation after germination and before harvest, height of plants, height of apical part of the lowest pod from the ground and yield. The results imply that the most effective way of seed treatment is the complete seed treatment, which ensured the yield of 3.29 t of seeds per hectare (average for three years), the second best was the treatment with the compound Lexin, thanks to which the achieved yield was 3.18 t of seeds per hectare.

Keywords: soybean; emergence; biostimulant; humic acid; auxins

Healthy and vigorous seeds play the key role in successful production of any crop. That is why the vigour of seeds is one of the basic factors influencing not only the quality of crop stand establishment, but also its productivity (Weise 1984, Finch-Savage et al. 2010, Pazderů 2015). To support the health state and the vigour of seeds, a treatment by biologically active compounds has been used for many years, next to traditional fungicide and insecticide chemical treatments (Procházka et al. 2015b). The seed treatment is either biological, chemical, mechanical or eventually physical process or a process formed by different combinations of named procedures serving to decrease negative effects of different external or internal influences and on the contrary to support the seed germination, seed vigour and subsequently even formation of healthy plants with increased production potential (Khanzada et al. 2002). Many authors mention the quick decrease of vigour and germination percentage of leguminous seeds, including soya (Maity et al. 2000, Murthy et al. 2003, Hnilička et al. 2013). For example Maity et al. (2000) and Goel et al. (2003) mentioned various ways how to slow down the seed senescence of these crops. According to the authors mentioned above, some compounds have certain biological activity that, among other properties, supports metabolism of seeds and that is why it is convenient to use them for stimulation of seed germination.

Biologically active compounds are various growth regulators, enzymes, compounds connected with plant bioenergetics, or even photosynthetic pigments producing protein complexes that participate to energy conversion of electromagnetic radiation on energy of chemical bonds (Dřímalová 2005). Many biologically active compounds demonstrated a positive effect on seed germination and consequent soya growth. According to some authors, biologically active compounds based on a mixture of synthetic auxins, humic and fulvic acids can have a very positive impact. Similar effects were observed in many experiments using synthetic analogues of some brassinosteroids that positively interact with auxins (Kohout 2001, Pačuta 2013, Procházka et al. 2015a). Even gibberellins or sac-

doi: 10.17221/225/2015-PSE

charides can be classified as biologically active compounds with anti-stress effects. They are effective mainly on the cell level (Dřímalová 2005, Procházka et al. 2015b).

The experiments conducted in the second half of the 20th century confirmed that auxins have a positive effect on seed germination and consequent plant growth (Dornbos 1995, Finch-Savage et al. 2010).

Since the 1980's, humic acids are more and more used as components of various biostimulants (Vaughan et al. 1985). Lignohumate belongs to the high-quality humates. Lignohumate, or more precisely Lignohumate B, is a liquid preparation based on humic substances originated in the process of organic transformation of waste from wood processing. It contains active parts of humin spectrum: a mixture of humic and fulvic acid in the ratio 1:1, which positively affects many biochemical and physiological processes of plants and positively affects soil (Tomášek et al. 2013, Procházka et al. 2015b). In the past, this effect was attributed to the formation of complexes between these two acids and other compounds like mineral nutrients. Nowadays, we know that the humic acids can stimulate plant growth and among others, they help increase not only availability, but also the intake, distribution and assimilation of nutrients by plants (Vaughan et al. 1985, Chen et al. 2004, Dobbss et al. 2007). The preparations that contain humates, phytohormones and, if needed, other compounds with hormonal activity, are more and more popular in Agriculture and Horticulture (Adani et al. 1998, Zhang and Ervin 2004, Pačuta et al. 2013). One of those preparations is Lexin (a liquid concentrate of humic and fulvic acids and auxins) that approved not only in experiments, but also in practice. Lexin has a positive effect on cell division, formation of vascular system, elongation growth, formation and growth of roots, lignification and on other anatomical and morphological properties and characteristics. The final effect is higher productivity, not only in quantity but also in quality (Procházka et al. 2015b). Other biologically active compounds with positive effects are brassinosteroids – phytohormones of the steroidal type. These hormones increase resistance of plants against stress, mainly drought, low and high temperatures, etc. They also increase the resistance of plants against soil salinity. It was also approved that they support the formation and growth of roots (Anuradha and Rao 2007).

MATERIAL AND METHODS

The aim of the experiment was to find out the impact of the seed treatment by biologically active compounds on the soya seeds and their field germination, formation of yield-forming factors and yield. In the experiment following biologically active compounds were used:

Lignohumate B (LIG) – mixture of humic and fulvic acids in the ratio 1:1;

Lexin (LEX) – concentrate of humic acid, fulvic acid and auxins;

Brassinosteroid (BRS) – we used substance labelled as 4154 that is diluted synthetic analogue of 24 epibrassinolide (2α,3α,17β-trihydroxy-5α-androstan-6-one);

Complete seed treatment (COM) – mixture of saturated sucrose solution, Lexin, fungicide Maxim XL 035 FS and adjuvant on the base of pinolene Agrovital.

The experiments were conducted during the vegetation periods between 2012 and 2014. The early-ripening cv. Merlin was used. With the intention of keeping the same method, the seeds were always treated right before sowing according to the diagram in Table 1.

In the determination of sowing amount we came out from the seed company recommendation. The sowing amount for cv. Merlin is 68 seeds per m^2. All variations were inoculated with nitrazon+ during the process of seed treatment.

The untreated control variant (UTC) was only inoculated.

The experiments were established with the method of long plots, in the cadastral area of the village Studeněves, Czech Republic (50°13'50''N, 14°2'54''E) at the altitude of 306 m a.s.l. Every vari-

Table 1. Diagram of soya seed treatment of individual variants

Preparation	Dose on 20 kg of seeds
Lignohumate B	25.7 mL
Lexin	6.5 mL
Brassinosteroid	2.2 mL of substance 4154
Complete seed treatment	saturated solution of sucrose 6.5 mL of Lexin 10 mL of Agrovital 20 mL of Maxim XL 035 FS

doi: 10.17221/225/2015-PSE

ation was duplicated three times with the area of 0.1 ha each. From the pedological point of view, the site had medium heavy to light arenic Cambisol on carbonate slope. The annual mean temperature on the site is between 8°C and 10°C and the mean annual rainfall is fluctuating between 450–550 mm. The forecrop before soya was spring barley in the first year, winter wheat in the second, and spring barley in the third year. Uniform cultivation technology was chosen for all of the variations. It is described in detail in Table 2.

The influence of the biologically active compounds on vegetation formation, on yield-forming factors an on yield itself was observed in all three experimental years. We observed these parameters: field germination, height of apical part of the lowest pod from the ground, height of plants, number of branches, number of fertile levels on plant and yield of seeds. The field germination was always detected in three different dates for better consideration of development dynamics of soya vegetation of individual variations. In case of upright vegetation until harvest (it was not flattened), we evaluated only the height of the vegetation. The yield was converted to the uniform humidity of 13%. The results of the experiment were elaborated by the statistical programme SAS (version 9.0, SAS Institute Inc., SAS Campus Drive, Cary, USA).

RESULTS AND DISCUSSION

The evaluation of this experiment was done using the results from three years (2012–2014). We can see in Figure 1 that the best seed treatments were the complete seed treatment and Lexin (field germination rate 87.5% and 86.2%). Both variations showed statistically significantly higher field germination in comparison with other seed treatments (Table 3). The development dynamics of these variations are more progressive than variation treated with preparations without auxins. Similar germination results were achieved by brassinosteroids. Resembling results were also achieved by Kohout (2001) or Procházka et al. (2015b).

Table 2. Cultivation technology of experiments in individual years

Year/term	2012/operation	Year/term	2013/operation	Year/term	2014/operation
August previous year	disc plough (8 cm)	August previous year	disc plough (8 cm)	August previous year	disc plough (12 cm)
October previous year	chisel plough (15 cm) deep cultivation (30 cm)	October previous year	chisel plough (16 cm)	October previous year	chisel plough (15 cm) deep cultivation (30 cm)
16.3.2012	fertilization (200 kg/ha NPK 15)	6.4.2013	fertilization (200 kg/ha NPK 15)	8.3.2014	fertilization (200 kg/ha NPK 15)
17.3.2012	pre-sowing preparation 2 × agri-compactor 5 cm	5.–7.4.2013	pre-sowing preparation 2 × agri-compactor 5 cm	8. and 10.3.2014	pre-sowing preparation 2 × agri-compactor 6 cm and 4 cm
19.4.2012	seed treatment inoculation and sowing	23.4.2013	seed treatment inoculation and sowing	21.4.2014	seed treatment inoculation and sowing
24.4.2012	treatment by PRE Afalon 45 SC (1.5 L/ha) Successor 600 (1.5 L/ha)	24.4.2013	treatment by PRE Plateen 41.5 WG (2.0 kg/ha)	21.4.2014	treatment by PRE Plateen 41.5 WG (2.0 kg/ha)
21.5.2012	treatment by POST graminicide Fusilade Forte (0.6 L/ha)	10.10.2013	harvest	21.10.2014	harvest
16.9.2012	harvest				

doi: 10.17221/225/2015-PSE

Table 3. Results of statistical significance

	COM	LEX	BRS	LIG	UTC	*LSD*	*n*
Field emergence	87.30[a]	86.20[a]	83.40[b]	75.70[c]	71.10[d]	2.2746	9
Stand density before harvest	51.60[a]	46.90[b]	42.70[c]	41.50[cd]	38.10[d]	4.1440	9
Stand height before harvest	81.01[a]	82.14[a]	79.11[a]	78.33[a]	78.37[a]	4.4531	9
Height of apical end of the lowest pod	7.77[a]	6.54[a]	6.40[ab]	4.79[bc]	4.68[c]	1.6711	9
Yield	3.29[a]	3.18[b]	3.08[c]	2.90[d]	2.85[d]	0.0507	9

Values with the same letters are not significantly different. COM – complete seed treatment; LEX – Lexin; BRS – brassinosteroid; LIG – Lignohumate B; UTC – untreated control; *LSD* – least significant difference; *n* – number of observations

Figure 2 it shows that the use of biologically active substances leads to increased field emergence. The greatest effect amounted to products containing plant hormones (auxins, brassinosteroids). The treatment with preparations containing only a mixture of humic and fulvic acids also had a positive effect, but not as considerable as when the mixture contained auxins.

If we want to achieve high and economically effective yield of soya, it is preferable to focus on important yield components. One of the fundamental factors affecting the yield is the number of plants per unit area. From Figure 3, it is clear that the variants treated by biologically active substances created a stand with a higher number of plants, which created a good premise for higher yield.

Procházka et al. (2015b) describes the problems of most soybean cultivars with the height of the lowermost pods from the soil surface. These pods are frequently in contact with soil surface, or just above it. This height is also according to the findings of our experiments is often a limiting factor in crop losses, which can be up to 0.5 t/ha in soybean. At harvest, cutterbar of harvester often cuts these pods or the pods leaves on not cut parts of the plant, causing thus considerable losses. The height of the apical end of the pod on the plant depends on the course of the year or cultivar, Figure 4 shows that this parameter can be significantly affected by application of seed treatment with biologically active substances. The highest placed lowest pods per plant were in variants COM and Lexin (height of the apical end of the lowermost pods of about

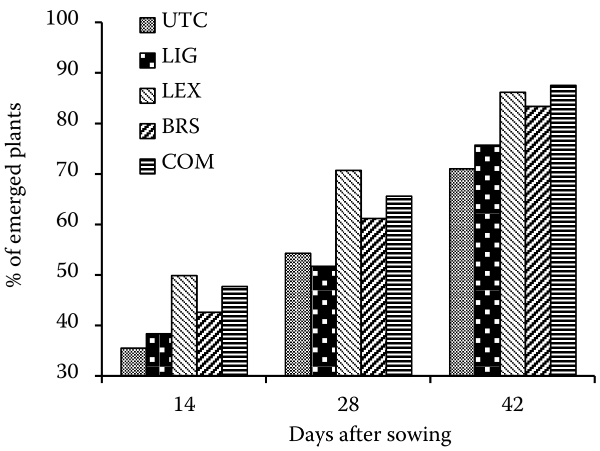

Figure 1. Progress of soya plants emergence in different treated variants in comparison with untreated control (average of three years 2012–2014). UTC – untreated control; LIG – Lignohumate; LEX – Lexin; BRS – Brassinosteroids; COM – complete seed treatment

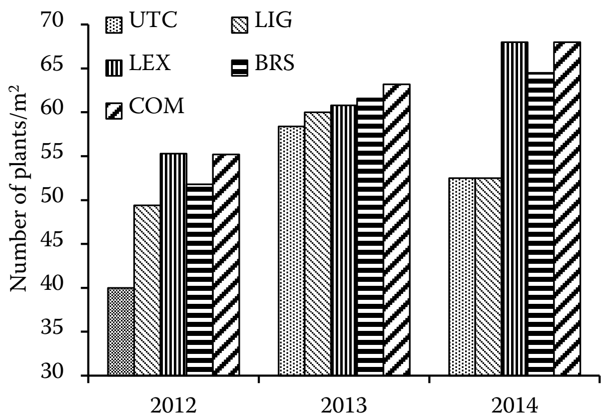

Figure 2. Crop stand densities of individual treated variants (phenotype phase 3rd trifoliate leaf) in years 2012–2014. UTC – untreated control; LIG – Lignohumate; LEX – Lexin; BRS – Brassinosteroids; COM – complete seed treatment

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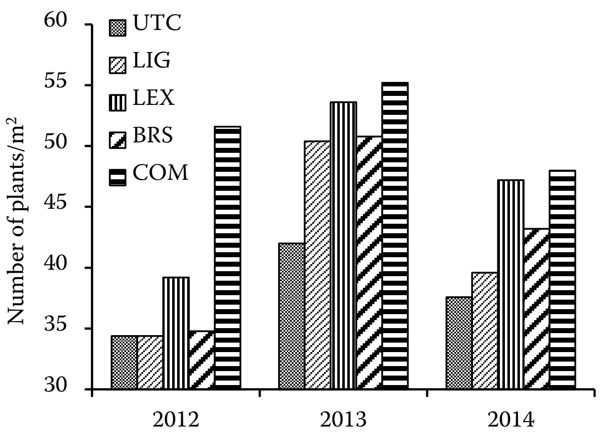

Figure 3. Crop stand densities of individual treated variants before harvest in years 2012–2014. UTC – untreated control; LIG – Lignohumate; LEX – Lexin; BRS – Brassinosteroids; COM – complete seed treatment

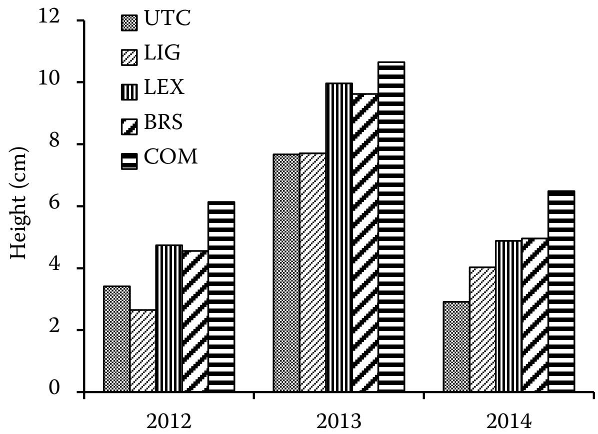

Figure 4. Height of the apical end of the lowermost pods from the soil surface in treated variants in years 2012–2014. UTC – untreated control; LIG – Lignohumate; LEX – Lexin; BRS – Brassinosteroids; COM – complete seed treatment

3.1 cm or 1.9 cm above the soil surface compared to the untreated control). The height of the lowermost pods for these two variants was statistically significantly different from other variants of treatments.

Figure 5 shows the yield of each variant in the years 2012–2014. From this graph it is clear that soya has greatly fluctuating yields, which is a common phenomenon among legumes. It is obvious that if the seed treatment by biologically active substances enables faster and vigorous crop stand, which is very compact and thus competitively developed, this could provide a higher crop yield rapidly after emergence. The highest yields were achieved in variants, whose seed was treated by complete seed treatment (3.29 t/ha – average for three years) and by the Lexin treatment (3.18 t/ha – average for three years). Very similar yield was obtained thanks to brassinosteroid. Similarity achievements of these three options are a sort of line in all parameters, which is due to the composition of these variants. Complete seed treatment includes, inter alia, Lexin. Similar results were achieved also in the research of Procházka et al. (2015a) with hydration seeds of forest trees. Lexin composition is, as already mentioned, a mixture of humic acids, fulvic acids and auxins, and auxin being supported in the initial growth stages of faster formation of plant tissues, and the formation of cell division and the growth rate (Finch-Savage et al. 2010). Vanneste and Friml (2009) also mentioned the positive influence of auxin to divide and grow plant cells. Brassinosteroids are a frequent precursors of auxins and they are in close interaction, which is reasoned in very similar results of brassinosteroid-treated variant. This determined similarity of the effect of brassinosteroids and auxins was also discovered for instance by Hradecká et al. (2009).

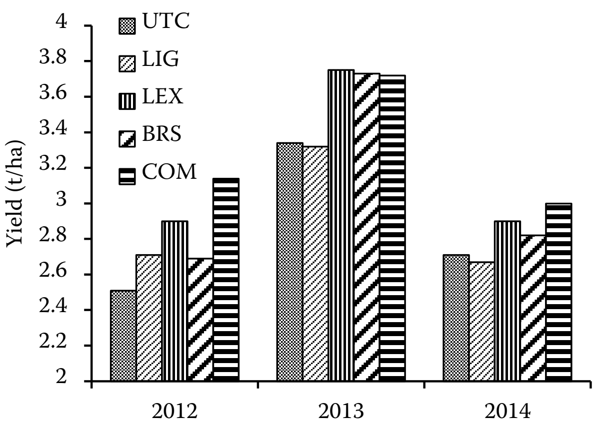

Figure 5. Yield of soybean seeds in treated variants in years 2012–2014 (expressed as 13% humidity in harvest time). UTC – untreated control; LIG – Lignohumate; LEX – Lexin; BRS – Brassinosteroids; COM – complete seed treatment

It is worth noting that the effect of seed treatment on plant height treatments (Table 3) has in soybean low importance in soybean.

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Received on April 9, 2015
Accepted on May 19, 2015

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