

## Stimulation of hop growth with biologically active substances

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In the farming technology of agricultural and horticultural crops, the use of biologically active substances has become increasingly important. These include, for example, preparations containing phytohormones or phytohormones in a mixture with other substances favouring the metabolism of plants. The successful use of these substances is based on thorough and continuous monitoring of the state and development of stands, the identification of potential or already existing stresses, especially in relation to the critical stages of ontogenesis in the crops concerned, and their adequate, truly rational use. The aforementioned substances usually improve plant rooting and vitality, resistance to stress, the appearance of their harvested parts, intensify photosynthesis, and thus enable the increase of the quantity and often the quality of the production.

In our experiments, we have tested e.g. Amalgerol, Atonik, BAP (6- (3-methoxybenzylamino) purine-9-riboside), Bioalgen, Brassinosteroids, Fortehum, GA3, Lexenzym, Lexin, Lignohumát, Melatran, Pentakeep, Rexan, Sunagreen, Synergim, with most cases providing positive knowledge and experience.

The results of several years of experiments and semi-operative treatments show that one of the most important biologically active substances is Lexin, which has proven beneficial effects in extra-root (but also root) application across a wide range of field and garden crops, significantly increasing their yields and quality. Favourable results have been obtained even when applying this product to seeds of different crops. As a result of the increased activity of respiratory and hydrolytic enzymes (carbohydrase, peptidase, esterase), seed storage endosperm substances were rapidly transformed, improving germ nutrition, and more vigorous germination and higher vitality among young plants.

The biological, and hence productive, effect of the use of Lexin lies in its substances, i.e. within the presence of unique humic and fulvic acids and synthetic auxins, which are substances that are extremely beneficial to plants, and are their natural and essential components. Also important is the ratio of the substances that interact positively with each other, thus enhancing the action of the drugs.

In addition to the fact that from the time of A. D. Thaer (1752-1828), humic substances have been considered the basis of soil fertility, the beneficial effects of some of these substances (e.g. fulvic acids) on the optimization of cell function and their energy potential have recently been regarded (by the scientific world) as one of the greatest discoveries of this century. Auxins are among the basic phytohormones of plants that not only

make a significant contribution to ensuring their integrity, but they can also be labelled as the main architects of plants. Without their presence in plants, the effectiveness of most other known phytohormones would be minimal, since their activity is conditioned by the presence of auxins.

We paid great attention to the issue of using biologically active substances in hops. We applied Lexin, (on whose advantages we would like to inform the growers in this paper) to both hop seeds and hop plants in hop gardens, in the forms of pickling (only for seedlings), grouts, irrigation and spraying. We have found, for example, that in the cases where Lexin was used in the vegetative propagation of hops, there is a faster and more powerful rooting of green cuttings, usually by 25 to 30%.

Table 1. Results of the experiment with the rooting of green hops cuttings, ČZU in Prague, 2009

Variant	Callus creation (in days)	Beginning of roots (in days)	Advanced root growth in root boxes (in days)	Chlorophyll content (in %)
Control	9	13	21	100
Pentakeep-S	7	11	18	117
Brassinosteroid	<b>6</b>	10	17	110
Sunagreen	<b>6</b>	10	17	104
Lexin	<b>6</b>	<b>9</b>	<b>15</b>	<b>115</b>
Lignohumát	9	14	20	98
Atonik PRO	8	11	18	111
Synergín	7	12	19	<b>115</b>

The hop plants in the hop garden were treated mainly by spraying, usually along with the application of other pesticides. Some of the results are shown in Tab. 2 and 3. The results obtained with the application of Lexin by spraying hop plants in the hop garden can be summarized as follows:

1. **After the application of Lexin in the pre-harvest period of the hops** (in order to increase the growth of cones, or increase their KH), the spring growth of shoots in the spring time of the following year was postponed, which has these beneficial effects:

- in cases of stronger late spring freezes, the damage on growing shoots of hops is reduced
- the cutting of hops removes less above-ground biomass (shoots), partly eliminating unproductive losses of stock from underground hop plant organs (lower energy losses of plants - better growth conditions)

- the later growth of hop shoots allows them to be introduced at the optimum time (often after the cold days of May 12-14), which is very beneficial for the annual ontogenesis of hops (slower plant senescence, postponement of the generative phase to photoperiodically more favourable conditions [premature flowering of hops does not occur] etc.)
- hop shoots are upright for a long time, often even stronger - they are easier to introduce, they are more tightly wrapped on the hop hopper; due to the larger netting of the tissues, at higher temperatures (in the afternoons), the shoots are less faded, which again makes it easier to introduce them (however, when introducing them, there is a need for greater sensitivity on the part of the workers to prevent the breaking of shoots, especially of their vegetation peaks - "cones") .

Table 2. Hops yield and quality - Sifejovice 2008

Variant	Application term - hop phase	Yield of dry hops (t / ha)	% KH in dry matter 18.8.2008	% KH in dry matter 26.8.2008	% KH in dry matter 29.8.2008
Control	without application	1,518	3,2	3,2	4,4
1. Brassinosteroid 2x	when reaching the ceiling of construction + at the time when cones become mature	1,841	3,2	4,5	3,6
5. Brassinosteroid 2x	when reaching the ceiling of construction + at the time when cones become mature	1,860	3,5	2,6	5,0
Lexin 2x	when reaching the ceiling of construction + at the time when cones become mature	<b>1,886</b>	<b>4,4</b>	<b>5,4</b>	<b>5,6</b>
Lexin + sucrose 1x	at the time of aging	1,670	3,2	4,5	5,2

*KH-Conductometric value of the cones (content of a - bitter acids), last term KH is harvest*

## 2. Application of Lexin after planting hop vines - in the vegetative phase of hops;

The treatment of hops after their installation depends on their development, the rate of growth of established shoots, the formation of the first shoot leaves and the overall condition of the plants (in relation to the current course of weather and agrotechnology, of course). In the growth phase of the hops they are treated with Lexin (mixed with pesticides) one to three times (at an interval of 10-14 days) with the following effects:

- the eventual slow extension growth of established vines, as well as premature formation of shoot leaves, obviously indicate the need for Lexin treatment; the treatment will strengthen the apical dominance of the main vines, intensify their long-term growth and reduce the formation of shoot leaves (especially the lower, least productive ones - due to the inhibition of auxiliary meristems), the vines grow more reliably to the ceiling of the hop structure (especially in young plants, in the first year after planting); experiments also suggested that the retardation of formation of shoot leaves in young plants after the treatment of Lexin (in the first year after planting) encouraged their rooting; this does

not mean that after Lexin the formation of shoot leaves is stopped, but it is not premature, excessive and unproductive in terms of plant development

- strengthening the apical dominance of established vines after Lexin treatment will somewhat dampen the growth of further (new - surplus) shoots of hop bucks, thereby limiting the energy (unproductive) losses of hop plants, lowering the demand for soil moisture and facilitating agrotechnology; in other words, the optimization of new shoots is made which, in the case of hops, almost always means their reduction (we observed exceptions such as an extremely strong - almost total reduction due to animals, when the treated plants continually tried to fill the missing shoots)
- improvement in the twining capacity of the initial vines throughout the entire vegetative phase of the hops (until the vine had attached to the ceiling of the hop structure); this greatly reduces the need for work to be done – after-implementation of hop vines especially in windy and dry weather
- after Lexin treatment the mechanical(and conductive) formation of hop plant meshes are intensified resulting in less mechanical damage (by wind, irrigator, etc.) and attacked by diseases and pests; the modification of the anatomical structure of hop plants, as well as other changes in their metabolism, also help during the shorter days following the summer solstice, i.e. the onset of the favourable photoperiod for short-day hops; at that time plants also increase their resistance to stresses of biotic and abiotic origins
- Lexin treatment partially eliminates the unwanted premature flowering of hops; the flowering period is shifted to a time that is photoperiodically (shorter days) and with regard to the temperature (as a rule, a decrease in temperature occurs) more favourable not only for its own course, but also for the formation of bitter substances in the cones
- the treatment of hops (especially in the evening) has proven to be very good, for example, during arid weather (intense sunshine, high temperatures, drought) where the long-term growth of vines slows down significantly (weak creation and intense decomposition of endogenous auxin due to increased activity of auxinoxidase enzyme)
- spraying Lexin is very good (e.g. compared to cytokinin-containing products) after hail damage to hops, because there is no excessive branching in damaged vines (formation of shoot leaves), their installation is easier and the consequent growth faster
- the application of the product slows down the aging of hop plants which occurs more intensively during stresses, including on soils with higher calcium contents, which reduces their production capacity.

### 3. The application of Lexin in the generative phase of hops

Lexin significantly supports the absorption capability of generative organs, thereby further increasing their dominance over vegetative organs (increasing the growth of generative organisms, i.e. flowers and cones at the expense of the growth of vegetative organs - leaves, shoots); the developmental potential is increased as a result of the activation of the so-called calcium channels in the plasma, providing water and nutrients to the flowers and cones. We treat hops at this stage up to 3 times (at intervals of 10-14 days) which brings about the following effects:

- during the flowering period, more flowers were retained (decreasing the occurrence of fading flowers, mainly in the lower parts of hop plants)
- the treatment contributed to the formation and growth of cones (Lexin generally promotes the formation of parthenocarpic fruits, which are the "unspoiled" cones by the male hop plants); the cones are bigger, with fewer of them fading; spindles, but especially the cone stems retain their functionality longer - with the cone stems, the release of middle lamellar cells and forming of a separating layer - and subsequently the fading of cones do not occur due to elevated levels of cellulase and amylase enzymes
- improvement in the transport of primary metabolites, nutrients and water into the cones (bigger sink) supports not only their growth (weight), but also the formation of bitter substances.

Table 3. Hops yield and quality - Hořesedly 2014

Variant	Application term - hop phase	Yield of dry hops (t/ha)	% KH in dry matter 12.8.2014	% KH in dry matter 21.8.2014
Control	without application	1,112	3,3	3,1
Ascophyllum nodosum	when reaching the ceiling of construction + at the time when cones become mature	1,196	4,2	4,3
Humic acids	when reaching the ceiling of construction + at the time when cones become mature	1,281	5,5	5,1
Fulvic acids	when reaching the ceiling of construction + when cones become mature	1,371	5,7	5,4
Lignohumát Max	when reaching the ceiling of construction + at the time when cones become mature	1,415	4,0	4,1
Lexin	when reaching the ceiling of construction + at the time when cones become mature	<b>1,566</b>	4,3	<b>6,3</b>
Lexenzym	when reaching the ceiling of construction + at the time when cones become mature	1,525	<b>5,8</b>	6,1
Pure Auxins	when reaching the ceiling of construction + at the time when cones become mature	1,493	4,3	4,7

*KH - Conductometric value of the cones (content of - bitter acids), last term KH is harvest*

In conclusion, Lexin, due to its composition, has a positive effect on a number of phenophases and the production of not only hops but also other crops. Its use is not only exceptionally versatile and very effective, but in specific cases also difficult to replace with other products.