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How to Achieve 20% Yield Increase

with Aranet Wireless Technologies

This is the story of Latvian companies working together and complementing each other's expertise, and starting a new trend in growing cucumbers that already sees acceptance in other countries, and creating a range of functional and proven sensors that are already a part of the products by the world's leading manufacturers of greenhouse equipment.

In this article, Horticultural Expert Andris Stuks goes into a deep dive in technologies and methods used to make Getlini EKO – already one of the most modern greenhouses in the world – more efficient and increase its yield by 20%

Andris Stuks

Senior Consultant at Synergy Solutions. Development and implementation of precise plant growing methods, remote cultivation in Russia and Lithuania

2020 – achieved 20% yield increase at Getliņi EKO

2018 – 2019 – Chief Agronomist at Agroinvest. 37.5 ha equipped with 100% LED lighting, part of the plants was reconstructed, introducing full automation and plant grafting

2014 – 2018 – Lighting Application Specialist at Philips Lighting. Developed and implemented in practice cucumber growing with 100% LED light

The most effective cycle with one planting

This year was a busy and successful one for Guntars Strauts, agriculturist at Getlini EKO, for Gints Antoms, Aranet wireless sensor brand manager, and his team at SAF Tehnika, and for Andis Stuks from Synergy Solutions who develops new methods for growing vegetables in covered areas.

A new precision cucumber growing method for covered areas was developed and perfected. Its effectiveness has been confirmed by this year's harvest yields at Getlini EKO.

A unique result that is unprecedented elsewhere in the world has been achieved this year in Latvia: one square meter (m^2) at the Getlini EKO greenhouse yielded 399 fruits, that is, 105.1 kg of cucumbers that were planted only once during the winter/summer cycle, from 13 January to 10 July 2020.

This was done using **100% LED lighting**, as well as the **precision cucumber growing method** and **wireless sensors** developed in Latvia. Other companies working in the greenhouse business have confirmed that something like **this was achieved for the first time in the world, and so far it has been the most effective cycle with one planting.**

About the project

This project began in September 2015, when the LED lighting tests in cucumber growing started under the management of Andris Stuks, in conjunction with the **Warsaw University of Life Sciences** (SGGW) and in cooperation with **Philips Lighting**. At the time Getlini EKO was planning the construction of its new cucumber greenhouse, facing a choice of what lighting technology to go for: either the industry-standard high-pressure sodium lamps or the new, unproven and little-tested LED lights. The motivation for Getlini EKO to start this test was to demonstrate that LED lights can generate equivalent or even better yields than the usual methods.

When the results of the cycle of long cucumbers in SGGW became known in May 2016, it became clear that Getlini EKO was most likely to choose LED lighting, because:

— **The yield of long cucumbers in the experiment exceeded the yield in industrial greenhouses in both: total kilograms and energy resource consumption per kilogram.**
— **In the parallel experiment with an average cucumber variety with 3 types of lighting, the 100% LED lighting also showed the best results in terms of kWh/kg, light efficiency (grams of product per unit of light) and total yield per m².**

The world's first cucumber greenhouse with 100% LED lighting

On 24 May 2017, Getlini EKO opened the world's first cucumber greenhouse, where LED lighting is used as a source of light assimilation. From day one, a widely used method, fruit rationing, was used in Getlini EKO to grow cucumbers, leaving only as much fruit as possible to grow in the planned amount of light.

According to calculations, the weekly yield in Getlini EKO should not be less than 4.2 kg/m²; respectively, at a plant density of 3.56 plants/m² and the planned average fruit weight of 260 grams, not less than 4 and not more than 5 cucumbers should be collected from a plant. To achieve this number of fruits, in the weeks when the plant produces 7 leaves, the formed fruit must be removed from 2 leave partings.

The first cycle of cucumbers took place as a training, during which the employees learnt their working methods and perfected their professional skills so that they could work at full capacity in the next cycle. **It became clear during this cycle that even a greenhouse as well-equipped as the new cucumber greenhouse in Getlini EKO does not measure such important things like: how the plants feel and how they react to changes in temperature and air humidity.**

Need for the climate and plant measurements

The second cucumber cycle in 2017 already took less time, **but the need to measure the plants themselves, and not the climate within the greenhouse alone, became even more evident.** This view was supported by the fact that, inexplicably, what had worked at SGGW, did not work at Getlini EKO, as the plants were transpiring less water, and even though the relative number of fruits was sufficient, some of the fruits stopped growing at some point. It was specifically the stopping of fruit growth that caused the failure to meet the planned harvest rates in 2017.

It is worth pointing out that in 2017 the scope of equipment for monitoring plants was limited and its price was disproportionate to the yield in addition to the fact that the level of knowledge in using it was very low. Inquiries revealed SAF Tehnika – the company right here, in Latvia, that makes wireless sensors, under brand name Aranet, for measuring temperature and humidity.

3 factors worked in favor of Aranet sensors: the approach to the development of new products, the price and the most important – their mobility, which no other sensor maker could provide in this price bracket. **The key advantage of Aranet sensors** is that in a greenhouse you can use them up to a distance of 150 m from the base station, obviating the need to invest in cables and other equipment. A meeting with the company's representatives resulted in an **agreement that Aranet will design the sensors for measuring the plants and these sensors will be tested at Getlini EKO.**

The first Aranet base station was set up at Getlini EKO in January 2018, equipped with the sensors available at the time to measure ambient temperature, relative air humidity and the level of CO_2. The temperature sensors were installed at different heights: at the top end of the plant, in the midsection and at the bottom, where the fruit is. That helped us realize that our previous assumptions and understanding of heat behavior within the greenhouse had been incomplete. **It turned out that on a sunny day the temperature differential between the top end of the plant and the part where the fruit is can be up to 2 degrees.** As the top end is warmer, it is developing faster than the fruit. While in winter, with the full heating on, the air around the fruit is up to 3 degrees hotter than the air at the top. As the ambient temperature changes, so does the relative air humidity, the capacity of the plants to transpire water and ultimately also the water consumption.

Setting these sensors up at the same height in different locations of the relatively small greenhouse revealed that the ambient temperature can fluctuate by 2.5 degrees. This factor must be taken into account in grading the fruits, and **with these findings we could finally explain, why different greenhouse areas had a 7% difference in yield during the first year.** In the cooler end of the greenhouse, the temperature drop was 1.5 degrees at night and up to 2.5 degrees during the day, resulting in lower growth rates there, which meant that more fruits would have to be left to maintain an equal yield thought the greenhouse. Despite the various issues, the first winter/summer cycle, which takes place between 13 January and 6 July, yielded 287 fruits or 71.8 kg/m².

With the training that started during the 2018 winter/summer cycle, the same cycle in 2019 led to a harvest as high as 315 fruits/84.2 kg/m².

Getlini EKO managed to achieve a 17% increase in its yield thanks to changes in its heating strategy, adjusting the temperature in individual heating circuits depending on the time of day, improving the fruit grading methods and using an equivalent amount of energy resources.

This success confirmed the belief that more analysis of the growing conditions and a more precise approach to growing can pay off.

How to get the planned harvest rates?

Despite the good results, the previous two winter/summer cycles yielded no answer to the question as to why some fruits stopped growing early, which was the main reason for not meeting the planned harvest rates. None of the possible causes suggested by other growers was found to be true, and we had to look for a solution ourselves.

In mid-2019, in conjunction with Synergy Solutions, Getlini EKO started **developing its own theoretical plant growing model** that would make it possible to separate the growth of the vegetation (leaves, stems and roots) from that of the fruits. The purpose of this model was to estimate a correct balance for the plant, with such factors as the plant density and the number of leaves and fruits per plant. We analyzed the results for the previous two years, as well as the plants registered, determining what measurements were still missing. By 2019,

the Aranet range of products already had the sensors we needed: PAR (photosynthetically active radiation) sensors, stem diameter sensors and weight sensors with an accuracy of up to one gram.

In Autumn 2019, weight sensors were installed at the Getlini EKO greenhouse to control watering amounts and water consumption, with a separate system of weight sensors for monitoring the weight of the plant. Using these during the autumn/winter, we collected the data necessary for improving the mathematical model.

The model is based on simple principles: first, if you know the total amount of light provided within 24 h, you must ensure that enough water is consumed and transpired for this light to be used in full, because the efficiency of photosynthesis is proportional to the amount of water transpired. Secondly, the amount of sugars generated as a result of photosynthesis must match the growth needs of the plant, which we can regulate through temperature and the plant's weight.

Of all these sensors, the plant weight sensors have so far turned out to be the most useful. There are a few methods for monitoring the substrate, but weighing the plant is the most accurate way of assessing plant growth.

By weighing the plants, we could finally observe what we were interested in: the plants growing. Synergy Solutions developed powerful tools for processing data and controlling growth, of which two are especially effective: comparing current growth with the growth during an equivalent period in previous days, and correlating it with ambient temperature, humidity and amount of light.

Because we could monitor the plant's reaction to changes in ambient conditions both in real time and in comparison to previous days, we introduced slight adjustments in climate settings every day, so that the resulting plant growth would be as high as possible. We observed a clear reaction of the plant to changes in air humidity; the effect of temperature on growth was less pronounced, which is why we maintained a lower temperature during the artificial day (i.e. at night, with lighting on), and allowed a higher temperature during the natural day, to use the energy of the sun in a more efficient way.

Our observations revealed that the biggest factor affecting plant growth was the plant's initial weight, because it essentially depends on the number of cells that can divide, whereas the temperature determines the speed of such division, and the light and available sugars are a measure of energy for such growth.

Improvement of other techniques

In addition to the new climate settings, certain improvements were introduced in work methods as well. We changed the fruit grading method, basing it on matured fruits, and leaving only the necessary number of fruits each time. Leaves were cut off whenever they no longer contributed to growth; we paid less attention to the leaf surface index.

In January 2020, we began measuring light inside the greenhouse, which made it possible for us to determine the total available amount of light with much more accuracy.

The fact that the choice in favor of this method was correct was made evident when we cleaned the roof of the greenhouse:

According to our climate computer, because the glass was dirty, the greenhouse was getting 26% less light than it should have. Such error in the amount of light can have dire consequences, as the plant does not have the energy to grow and produce fruits, and has to do it at the expense of the roots, which has long-term effects.

The harvest rates achieved at Getlini EKO this year come from careful data analysis, of monitoring and managing the plants. This result is a consequence of small changes in many parameters and operating methods, taking into account the reactions of the plant and providing it with all its needs. This makes it a precision method for growing cucumbers, which can help a responsible agriculturist like Guntars Strauts to achieve even better results.

You need to know the amount of light

One can also point out that such methods are only useful in greenhouses as advanced as the one in Getlini EKO, though it is not exactly true. Unlike, say, common plastic film greenhouses, at the Getlini EKO greenhouse you can control every climate parameter, and for all these options, Getlini EKO could not fulfill its production plans by growing its plants without monitoring their reactions to change.

Monitoring plant growth in this manner is simple and easy to understand. It can be of value to the owners of typical plastic film greenhouses that are rather common in Latvia.

When using this approach in a greenhouse without artificial lighting, and whenever a prolonged reduction in the total amount of light is expected, it is recommended to pick smaller fruits, thus relieving the plant and giving it reserves for maintaining its roots and growing new fruits, thus preventing fruit abortions. **Our observations show that a reduction in the 24-hour average temperature does not result in a proportional reduction in plant growth. By monitoring your greenhouses, you can determine when the time is right to start picking smaller fruits.**

Monitoring plant growth can also be valuable in greenhouses where soil is used as a growing medium, because knowing the growth rate makes it possible to determine the

time to water the plants: a deficit of water causes a significant reduction in the growth rate of the plant, and it is important to water the plants before they start losing weight.

Lighting is the biggest limiting factor. Total light is less used as a parameter in open-field agriculture, where total temperature is more important. When growing plants in greenhouses, one must know the total light they receive, because unlike the plants grown in fields which are harvested at the end of the growth cycle, greenhouse plants, such as cucumbers, undergo multiple harvests during the growth cycle, meaning that the **total light is a more important parameter in determining productivity. Even in a common plastic film greenhouse, it is enough to monitor total light compared to its yield for a couple of weeks to realize that the total light parameter can be used to predict productivity.**

The development of an equivalent method for growing tomatoes has begun based on the experience growing cucumbers. We will see the results of this work in summer 2020, once the full tomato cycle is completed at Getlini EKO.

Watch the video to learn how your horticulture business can benefit from implementing a wireless sensor ecosystem to optimize growth!