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Carbon LED: knowledge development and demo in one

Tomatoes react to far-red light: from almost zero to 25% more

LED lighting and far-red light were combined in the second and third trials. The researchers believe there is still a lot to be gained from this.

High-tech greenhouse horticulture is a complex field. No-one has enough innovative strength to achieve everything on their own. The Carbon LED project, which focused on reducing electricity consumption and achieving high yields and product quality in tomato, is a shining example of how people in the sector can successfully work together and benefit from each other's innovations.

"In our sector we are seeing a drop in the amount of energy used to heat greenhouses. But on the other hand the area under supplemental lighting is continuing to rise, which pushes up energy consumption and increases the heat load. This can be a problem in crop production. We wanted to see whether LED lighting could take us down a new path," says project leader Anja Dieleman, researcher at Wageningen University & Research in the Netherlands.

Collaboration

The Carbon LED project was a collaboration between WUR, Nunhems, Signify (formerly Philips Lighting), INRA and Startlife aimed at designing energy-efficient lighting systems for the greenhouse horticulture sector. The project was funded by Climate KIC, Europe's leading knowledge and innovation network, which is committed to reducing greenhouse gas emissions.

"The starting point of the project was: how can we work together to develop a lighting system based on LED that will be accepted in the commercial setting?" Dieleman says. "And we achieved that. The project gave us new insights and shows growers what this kind of lighting does and what results it can achieve. Ultimately, they are the ones who make the decisions on investing in lighting and varieties." The tests were run in three sections of the research greenhouses in Bleiswijk over the past three lighting seasons.

Existing lights enough

In the first year, the greenhouse trial focused mainly on the plant architecture and the beam angle of the LED lights. "We tested commercially available interlighting and prototypes with a different beam angle based on calculations with a 3D model from WUR," says Esther de Beer, research and predevelopment manager at Signify. "We grew four tomato varieties with different plant architectures in the trial

and found that they all responded the same to the light distribution. The existing interlighting came out best." The company therefore decided to keep the beam angle of the existing design unchanged in the new product generation. The supplier is focusing its improvement efforts on producing more energy-efficient models and already has a third generation on the market.

De Beer sees significant added value in the collaborative approach. "We could have carried out trials ourselves, but our interaction with the breeder brought additional benefits. And that was a firm endorsement that we were on the right track."

Trials at the breeder

Following on from previous results, the members of the consortium decided in the second lighting season – from 2016 to 2017 – to look at the effects of supplemental lighting with far-red light on various tomato varieties. Red light increases assimilate mobilisation to the fruits.

Frank Millenaar, tomato pre-breeder at Nunhems: "We conducted the study in Bleiswijk with the two pre-commercial cocktail vine tomato varieties Extension and Foundation and the cherry tomato Competition. We grew them all under LED lighting with and without extra far-red light. They all got the same amount of PAR light. In our own nursery we had 11 cluster tomato varieties, also partly commercial and partly pre-commercial. We used roughly the same trial setup but with SON-T and LED interlighting with and without far-red light."

Surprising effect

To everyone's surprise, there were big differences between the varieties. "Reactions to the far-red light varied from almost zero to 25% higher yields. What's more, the quality of the fruits was also better, partly due to the higher Brix. For us, the fact that the varieties reacted so differently to far-red light was an important lesson. It's something we can use in our breeding," Millenaar says.

Anja Dieleman: "Differences in genetic variation show that there is a lot of potential that is as yet untapped."

Esther de Beer (left), Frank Millenaar and Anja Dieleman were responsible for different parts of the project. They are happy with the results.

According to project leader Dieleman, the fact that there are differences in genetic variation is an excellent starting point for further research. There is a lot of potential there waiting to be exploited.

Extra far-red costs electricity

Dieleman: "Providing extra far-red light does use more electricity, though. So in year 3 we looked at whether far-red still makes a difference when you keep your electricity consumption at the same level." In the trial, some of the red/blue PAR light was replaced with far-red light. One part was lit with 210 µmol/m²/s red/blue LED light and another part with 35 µmol/m²/s far-red light combined with 175 µmol/m²/s red/blue light. This was done in the varieties Progression and Extension, which had reacted positively to far-red light in previous trials.

"The use of far-red light seemed to go well to begin with, but by the end of the lighting season we found that yields were down on those under red/blue light only," project leader Dieleman says. "Although the tomatoes grown under far-red light did have a higher Brix. So the picture isn't that simple yet."

"We will keep on innovating and will continue our research. We expect further gains to be made in aspects such as the interaction between different types of lighting – when and when not to use far-red, for example – and in the choice of variety," De Beer adds.

Commercial setting

Applying the knowledge gained in the commercial greenhouse setting was another major part of the project. That took the form of open days, courses and articles in trade journals. "We had around 250 visitors on our open days on LED lighting at our trial site in Bleiswijk. Also, WUR ran courses on LEDs in greenhouse horticulture and vertical farming which proved very popular with growers and other businesses," Dieleman says.

Following on from the positive results of the Bleiswijk experiments, a practical trial with far-red light in tomato was run at Prominent with an oversight committee consisting of representatives of most of the growers' associations. The committee liaised closely with the researchers working on the Carbon LED project.

Dieleman is happy. "We set out to save energy, but the important factor for growers is yields. There's nothing better than when higher yields attract attention. That's a neat way to achieve the aim of the project."

Summary

The Carbon LED project has come to an end after three lighting seasons. Various partners collaborated on designing energy-efficient LED lighting systems for use in greenhouse horticulture. The main conclusions are that up to 25% higher yields can be achieved as a reaction to far-red light but that there are big differences between varieties.
Far-red light doesn't seem to increase yields when electricity usage is kept at a constant level. The project is a shining example of successful collaboration and innovation sharing in the sector.