Improving energy efficiency in greenhouses by crop recording

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Published in the Grower 61(4), 2006, p. 33-35
Funded by Horticulture NZ and MAF Sustainable Farming Fund

Rising fuel prices push greenhouse operators to improve their energy efficiency, which is the amount of production per amount of energy used. There are two ways to enhance the energy efficiency: by reducing the energy input and by increasing the production. There is scope for both in most New Zealand greenhouses. This article is about using 'crop recording' as a tool for increasing the production, and hence enhancing the energy efficiency.

Energy efficiency
We dare to say that both the energy use and the production can be improved in most NZ greenhouses. Many growers in NZ achieve only three-quarter or even half of the top production overseas. This is despite the better growing conditions here, especially in the winter half-year. The energy consumption can be reduced as well. Last year Peter Mos from the Netherlands did energy audits in ten NZ greenhouses and found room for improvement at every place he visited. Improved energy efficiency means that the costs of energy are covered by more income.

Crop recording
Every grower wishes to improve the production, but how to make that happen? It requires improvements in management, either regarding growing conditions, crop training, fertilisation & irrigation, pests & diseases, or all of them. It starts with understanding where and when things go wrong, and the next step is knowing how to correct them. This is where 'crop recording' comes in. Crop recording is a way of monitoring plant growth and relating that to the growing conditions. Weekly observations are put in a spreadsheet, and displayed in graphs. The grower or a consultant can see where the graphs deviate from the ideal situation. Recommendations are given on how to correct that by changing the greenhouse climate, watering regime or plant nutrition.

Vegetative / generative balance
The art of growing is to make the best use of the natural light and to convert light into fruit. After all, light is the factor that determines growth and production. Light is a given factor and cannot be controlled very well. Therefore all control actions must be based on the light level. For best results, the plants need a good balance between growth and fruit production, also called vegetative / generative balance. Plants that are too vegetative are characterised by a strong thick head, strong truss stems, even kink trusses, large leaves, but poor fruit set. In contrast, a very generative plant will have many fruit and a poor thin plant head.
A grower can influence the plant balance. Plants produce sugars (by photosynthesis), and the grower can influence the amount of sugars available and where the sugars go: to the fruit, growing point or roots. It is a matter of looking at the plant balance: generative, vegetative or just right? If the plant is too generative, more sugars must be directed to the head of the plant. If it is too vegetative, more sugars must be sent the fruit, and new fruit set must be stimulated. The tools to influence the balance are the temperature (especially the night temperature and the difference between day and night), humidity, CO2, EC or CF, irrigation regime (frequency, amount per irrigation cycle), plant management (plant density, keeping an extra head, leaf picking, truss pruning) and more.

Aim of crop recording

What does crop recording have to do with the above? Crop recording involves weekly observations on ten typical plants. It helps to make clear what the condition of the plant is. It is an assessment of growth, development and vegetative/generative balance. Crop recording graphs can show trends demonstrating in what direction the plant is developing. Subsequently, informed decisions can be made on climate control and water management. Secondly, crop recording is a tool to build up a record of what happened in a growing season. This helps decision making in following years and avoiding making the same mistakes again. Crop recording systems are commercially available from overseas, but unfortunately even the larger growers in NZ find them expensive. Some consultants in NZ are using their own crop recording system.

New project

Recently a new project has started aiming at developing a crop recording system that is practical and affordable for NZ vegetable growers. The system aims at improving energy efficiency by increasing the production with the help of crop recording. The project is funded by MAF-SFF, HortNZ and supported by HortiCentre. The ground work so far has been done by horticultural consultant Roelf Schreuder. He designed the plant measurements and developed a spreadsheet for recording the data and making the graphs. But since Roelf has taken up another position, the project is now carried out by Bert Houter and Elly Nederhoff (all of Technolutionz). In this project, we would like to work with six growers who are prepared to invest time in crop recording. The growers must grow tomato or capsicum in a controlled greenhouse. In return for their efforts, the growers will receive guidance from the Technolutionz team. The project will run for 2 years, but signing up can be for one crop season.

Pilot study

Prior to this project, a pilot study on crop recording has been carried out at cherry tomato grower Peter Fausett in Patumahoe. In two greenhouses, a recording plot of ten plants was set up shortly after planting. Every week Peter did the plant measurements and typed some inside and outside climate conditions in a recording sheet. Roelf Schreuder received the data per email, and made graphs to demonstrate what had happened. The graphs were used for decision making and advice, and for estimating harvest in the coming weeks. Roelf advice included climate control, plant nutrition and disease control. For instance, Roelf's advice on vent control reduced energy use in winter and improved the growing conditions in summer. By nearly closing the wind side on hot dry sunny days, the humidity stayed above 60%, without too much increase of temperature. So the crop remained active and suffered far less from the heat. A range of topics were discussed such as changing from pumice to cocopeat, growing on cocopeat, water disinfection and plant density. This project found that the plant density could be greatly increased, leading to higher production per m^2.

Observations by the grower

In the pilot study the observations needed for crop recording were established, which are now requested from the six growers participating in the new project. See also Figure 1. These recordings involve:

1) weekly crop recording on 10 plants (number of flowers and fruits, leaf length, stem length, and for tomatoes stem diameter).
2) weekly recording of average growing conditions (average daily radiation sum, average temperature and humidity inside, average temperature outside) and water management (water supplied, drain percentage, pH, EC or CF of drip and drain), as well as fuel consumption.
3) monthly sampling of the nutrient solution, and having these samples analysed at Hill laboratories (if necessary).
4) sending the data to the project consultant.

Role of the consultant

Project consultant Bert Houter will set up the plots of ten plants at the participating growers at the beginning of a new crop season, and will demonstrate how to do crop recording. He will visit the grower at least four times per year, and provide remote consultancy once a month or on-call. Typically he will get the crop recording data from the grower every week via email. Bert will further develop the spreadsheet, and do the data processing and return the output (graphs) to the grower every week. These graphs will help the grower to better understand the growing process and the influences of his actions. Bert will also study the output and seek relations between growth and growing conditions. Based on this he can give advice on crop management, greenhouse climate control, and potentially nutrient supply.

Advice tool

The output of the spreadsheet will be graphs, tables and numbers. See example in Figure 2. Initially, the recommendations for growing will have to come from the project consultant Bert Houter. At a later stage, the system will be partly self-explanatory and better understandable for growers and other consultants. The spreadsheet will come with an accompanying CD or DVD that will demonstrate how to do crop recording, and will provide some basic interpretation of graphs and recommendations for growing. The crop recording system and supporting CD or DVD will be made available to all tomato can capsicum growers who are member of HortNZ.

Week	1	2
Greenhouse climate	**2 Feb**	**9 Feb**
Average day temp. (C)	*24.2*	*22.2*
Average night temp. (C)	*19.8*	
Av. day humidity (%)	*71*	
Av. night humidity (%)	*88*	
Average CO2 (ppm)	*405*	
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Week	1	2
Plant measurements	**2 Feb**	**9 Feb**
Length growth (cm/wk)	*19.8*	*18.5*
Leaf length (cm)	*45.4*	*42.6*
Diameter of head (mm)	*13*	*11*
Set truss	*8.3*	*8.7*
Set fruits per plant	*22.5*	*29.3*
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Production (kg/m2)	*1.2*	*0.9*
….		

Week	1	2
Water supply & nutrition	**2 Feb**	**9 Feb**
Volume applied (litre/m2)	*6.0*	*8.5*
Drain volume (litre/m2)	*2.4*	*2.5*
Drain %	*40*	*29*
Average pH in	*6.1*	*6.2*
Average CF in	*24*	*25*
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Figure 1: *some of the data the grower collects and enters into the spreadsheet every week.*

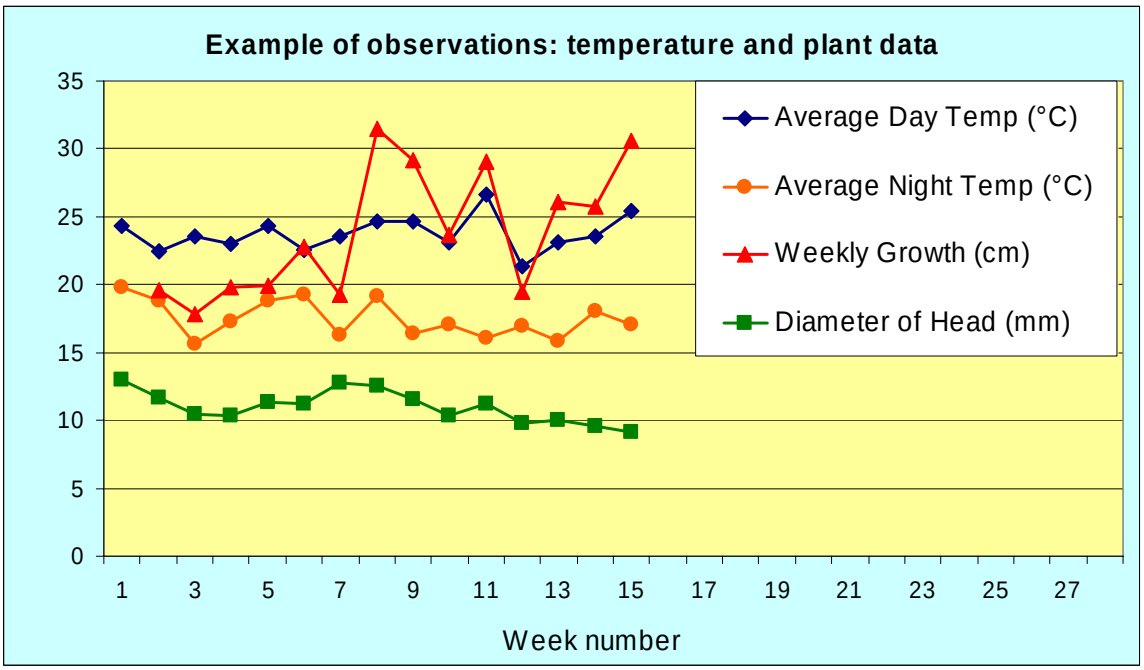

***Figure 2**. Plant measurements (e.g. stem diameter and weekly stem length growth) as well as weekly day and night temperature.*