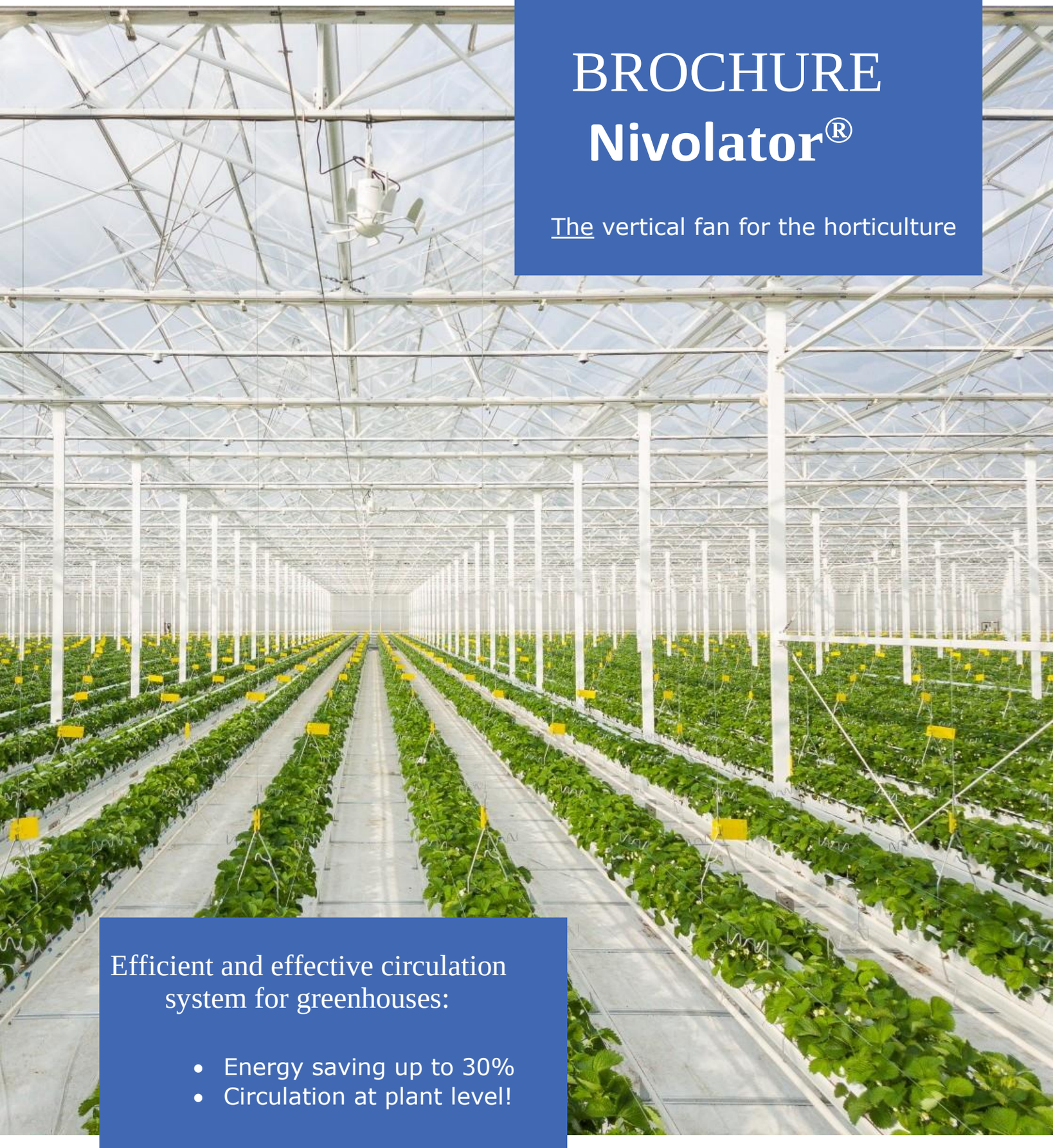
BROCHURE
Nivolator®

The vertical fan for the horticulture



Efficient and effective circulation system for greenhouses:

- Energy saving up to 30%
- Circulation at plant level!

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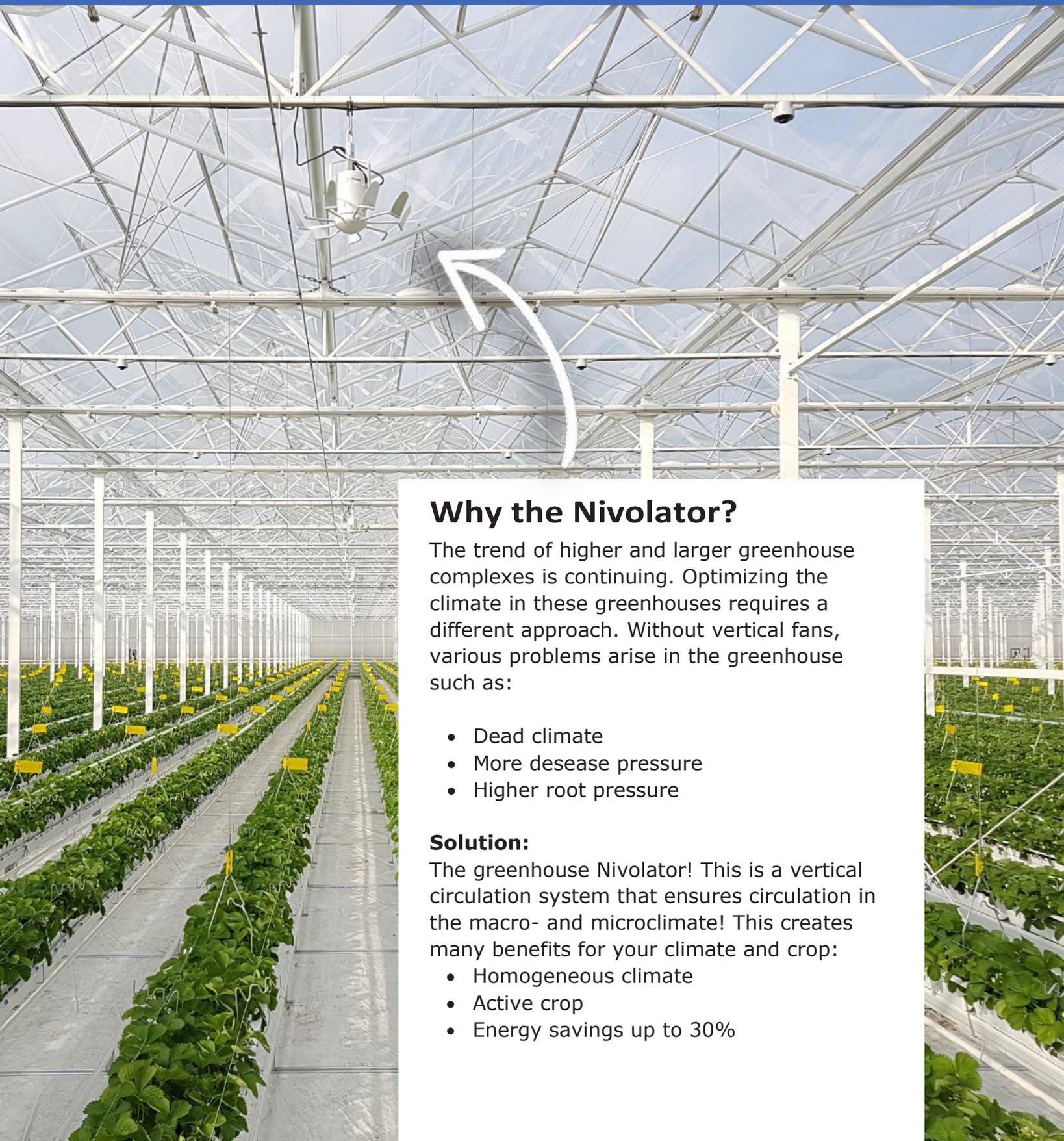
3. Greenhouse Nivolator®



Why the Nivolator?

The trend of higher and larger greenhouse complexes is continuing. Optimizing the climate in these greenhouses requires a different approach. Without vertical fans, various problems arise in the greenhouse such as:

- Dead climate
- More desease pressure
- Higher root pressure

Solution:
The greenhouse Nivolator! This is a vertical circulation system that ensures circulation in the macro- and microclimate! This creates many benefits for your climate and crop:

- Homogeneous climate
- Active crop
- Energy savings up to 30%

The advantages

- Homogeneous temperature and CO2 distribution throughout the
- greenhouse Active crop, less diseases
- Energy savings up to
- 30% Energy-efficient;
- only 180 W Virtually
- maintenance free No
  draughts, no dead air
- Small vertical temperature gradient between roof and
- floor Ingenious air pattern

More than 60 years of experience with the Nivolator all over the world.

The well-considered design of the greenhouse 'Nivolator' has a unique air pattern. The Nivolator consist of nine raised blades producing a special conical concentrically directed air stream. The under pressure at the fan causes the air to stream from bottom to top, thus creating two air streams, represented by an inner and an outer cone. In this way an ideal air circulation is produced. The fan blades can be adjusted in order to obtain the correct cone. The greenhouse 'Nivolator' can be used with a huge variety of crops. This includes tomatoes, peppers, roses and other flower varieties, cucumbers, strawberries etc.

Technical specifications of the fan

	Type PVE-7/V9
Motor power	180 Watt / 230
Fan speed	Volt 700 rpm
Electrical	1 Ampere
current Airflow	8.000 m^3 / h

2. References and Researches

Discharge of moisture without a minimum pipe temperature

Vertical ventilation results in

More than one year ago *Onder glas* published an article about what is referred to as 'vertical ventilation'. Growers including the gerbera growers Aad and Nelleke Zuiderwijk, in Bergschenhoek, the Netherlands, acquired experience with the new technique, which was expected to result in a better glasshouse climate and lower energy consumption. The research, financed by the Ministry of Agriculture, Nature and Food Quality and the Product Board for Horticulture, has demonstrated that these objectives are achieved in practice.

TEXT AND PHOTOS: JOS BEZEMER

Wageningen UR Glastuinbouw (Wageningen University and Research Centre Glass Horticulture) in Wageningen and Bleiswijk and Hoogendoorn Growth Management jointly carried out the research into vertical ventilation. The researchers, Jan Bontsema (Wageningen) and Peter van Weel (Bleiswijk) have now completed the draft of their final report.

A brief recap of the problem: in traditional glasshouses moisture is discharged using a minimum pipe temperature and gaps in the screen. This costs unnecessary energy. On switching to a short-day treatment gerbera growers make even more intensive use of highly opaque blackout screens, which exacerbates the moisture problem. Consequently when night falls the screen is opened, resulting in energy loss.

Since gerbera is extremely vulnerable to Botrytis on the blossoms a reliable but also energy-conserving solution was required to prevent condensation on the blossoms. For this reason Wageningen UR Glastuinbouw sought a solution based on what is referred to as 'vertical ventilation'. Following a small-scale trial in 800m^2 of the glasshouse the entire Zuiderwijk glasshouse (2.5 ha) was equipped with Aircobreeze units, fans installed by Hoogendoorn Growth Management, with a vane design that achieves the vertical mixing of air layers.

No minimum-pipe temperature

Vertical ventilation has a marked effect, but as is always the case growers need to learn how to use the new technique. Gerbera grower Aad Zuiderwijk has now changed his methods and attitudes: for example, he no longer uses a minimum-pipe temperature. "There can't be a stagnant climate, the air must remain in circulation: condensation has to be avoided, there can't be any droplet formation. I always achieved that with a minimum-pipe temperature. However, vertical ventilation enables me to discharge moisture much more economically than by heating. It took a while to get used to the idea: it's not easy to abandon an ingrained custom. However, the new method is successful, and in fact I've forgotten the minimum-pipe temperature."

The grower determines success by factors including the Botrytis pressure. The researchers carried out measurements at a reference holding to enable them to draw reliable conclusions. The grower explains: "My Botrytis pressure has not increased in comparison to the reference holding, and the quality of my crop has not deteriorated. In addition, I don't see any deterioration when I compare the results with my holding's previous years: if anything, I see an improvement."

Lower energy consumption

The energy consumption also exhibited an improvement. Last year Aad Zuiderwijk's gas consumption was 20 to 30% lower than the reference holding's gas consumption – an appealing result that should nevertheless be placed in perspective. "It's a comparison

a more uniform climate and lower energy consumption

solely of two holdings" the researchers Jan Bontsema (who was also the project manager) and Peter van Weel explain. "All other holdings can exhibit different characteristics. At another holding the savings could be lower, although an even better result cannot be excluded. In general, it is possible to conclude that vertical ventilation results in both a better and more uniform glasshouse climate, and in energy savings."

It was important that the gerbera grower could fall back on the knowledge of the project team, and that everyone could view the charts of the glasshouse climate via Letsgrow.com. The grower uses the Aircomatic, a Hoogendoorn Growth Management software module, to control the fans and regulate the air humidity. Smoke tests had already been used to give a demonstration of the vertical ventilation principle to the many interested parties. Jan Voogt, from the software supplier, explains: "Smoke offers an ideal means of showing what happens to the air layers when you change the minimum-pipe temperature, open or close the screens, or switch the lighting on or off. It really does visualise the vertical air currents, and it reveals that vertical fans achieve excellent mixing of the air – with very little power consumption – and with all the concomitant benefits."

Information becomes a tool

For Aad Zuiderwijk the vertical fans and the associated software provide him new tools for his climate strategy. He says that he now makes more use of the charts generated by the climate program. "It would appear that when you let go of old customs it becomes easier to learn how to make use of new information. I now look at the charts more frequently to find out what they can tell me about the climate, and I rely less on vague impressions. The information really has become a tool, I can now work with more precision."

Peter van Weel notes that many growers have little understanding of the physics of glasshouse climates. He cites the belief that humidity can be reduced solely by heating as an example of a stubborn misconception. An active climate is achieved by a combination of the supply of energy and circulation of air, and all too often the latter is lacking in insulated glasshouses.

Peter van Weel: "In practice, the effect of a minimum pipe temperature on air circulation is much less than we think. Moreover, the idea that growers need to give extra encouragement to crop evaporation at night time is also a misunderstanding. Growers need to know more about the background if we are going to make major savings in the Dutch glasshouse horticulture sector. How can you reduce consumption if you don't really know what you are doing?"

Better decision-making

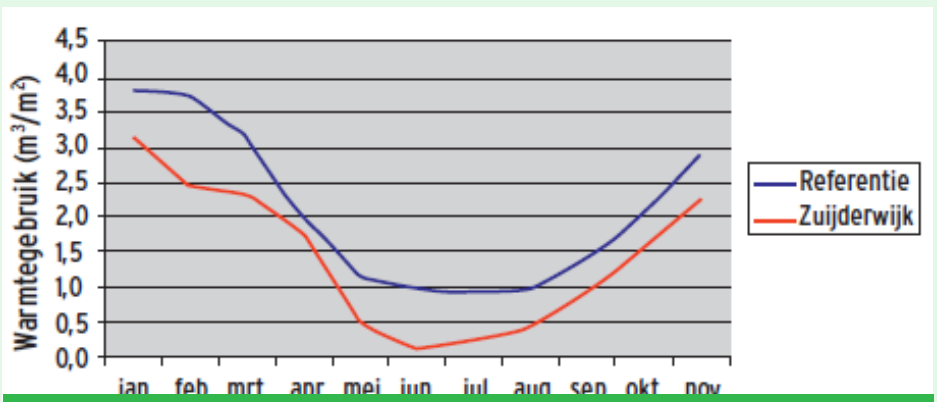
It should be noted that anyone who thinks that horizontal ventilation also keeps the crop sufficiently dry is mistaken. The horizontal air currents are concentrated in the region above the crop rather than in the crop, the location of the moisture problem. Horizontal ventilation also causes extra air currents under the screen, increasing heat losses through the screen. Vertical ventilation results in the same air displacement, but now in the correct direction: the heat is directed downwards, and air circulates in the foliage.

Aad Zuiderwijk: "The Aircobreeze creates a gentle vertical air current which is nevertheless sufficient to maintain a uniform climate and retain the air humidity within the required margins." Photo: Fotostudio GJ

Aad Zuiderwijk is of the opinion that vertical ventilation offers a further benefit: "Since the climate is more uniform the reliability of the values recorded by the measurement unit is automatically increased" he explains. "That's an important secondary benefit: my decisions based on the measurements are now taken on much sounder foundations."

In conclusion, Jan Bontsema says: "Wageningen UR Glastuinbouw will be publishing the final report of the research within the near future. It's certainly an example of good collaboration. All the participants were highly involved, and the

GRAPHIC: Energieconsumption



In 2008 grower Aad Zuiderwijk used up to 30% less gas than the reference holding.

The effects of vertical ventilation were examined at Aad and Nelleke Zuiderwijk's gerbera holding in 2008. It transpired that the technique resulted in a more uniform glasshouse climate and lower energy consumption. There was no deterioration in the Botrytis pressure or the product quality: both appear to have improved. Vertical ventilation offers the grower a new tool in climate control, which he has learnt how to use with the support of a number of specialists.

SUMMARY

Creating an active climate

Until now avoiding a stagnant glasshouse climate always required a great deal of energy. However, a new method is now available for the discharge of moisture from glasshouses without heating – and, consequently, without energy consumption. This is achieved with the Aircobreeze, a fan that results in vertical ventilation.

BY PETER GELEEN
Independent consultant

When the humidity in a glasshouse rises excessively during the night the moisture can be discharged by opening a gap in the screen and/or opening the windows further. However, this exposes the plants to the risk of a cold draught. Avoiding this risk is one of the reasons why the pipe temperature is increased, although increasing the pipe temperature in turn increases the evaporation rate and results in a further increase in the humidity in the glasshouse.

ACTIVE CLIMATE WITHOUT HEATING

The cold air above the screen always contains less moisture than the warm glasshouse air under the screen. This phenomenon can be used to reduce the moisture content in the glasshouse without heating, *and* without a cold draught. This is possible with the Aircobreeze, a fan operating at a low speed that displaces air vertically in the glasshouse. The fan is installed under the gap opened in the screen: a very restricted gap is then sufficient. The Aircobreeze mixes the dry, cold air above the screen uniformly with the humid, warm glasshouse air under the screen. The relative humidity under the screen then falls, without the risk of a cold draught. The moisture in the air above the screen is discharged by condensation on the glasshouse screen or by ventilation. Moreover, the very low air currents result in the equalisation of the temperatures under the screen and uniform evaporation – and, consequently, for an active climate without the need for heating.

The next step is comprised of blowing outdoor air into the glasshouse to achieve even greater energy savings. Wageningen UR Glastuinbouw (Wageningen University and Research Centre Glass Horticulture) in Bleiswijk is currently carrying out research into this principle using a double screen. This research is also reviewing the possibility of making even more use of the water-absorbent capacity of outdoor air. This could be achieved by heating the air to the glasshouse temperature (and certainly not any higher, since this would promote evaporation) and blowing the air under the crop and into the glasshouse. It is expected that this can achieve energy savings of 30 to 50 percent and, at the same time, reduce the Botrytis pressure.

IMPROVED MICROCLIMATE

Air currents created by vertical ventilation also eliminate temperature differences in the glasshouse, thereby reducing the risk of condensation (on the crop) and offering scope for a higher relative humidity. This offers benefits for the screening period, as well as when heating to the day temperature. Moreover the air currents around the plants achieve more uniform evaporation whilst virtually no energy is supplied. Consequently the use of the under net can be restricted. In addition, it is probably possible to avoid a variety of growth problems, such as damaged leaves, singed leaves, discoloured leaf tips or brown petals using only limited energy.

DRY CROP

Tonny Vink, manager at the Ruud van Schie organic growers in Ems: "The Bio Optimaal glasshouse gave cause to our introduction of vertical ventilation. Since we grow tomatoes in soil there is a great risk of condensation on the cold fruit during heating. For this reason we always started heating very early in the morning. However we are working on energy conservation, and we decided to try using vertical ventilation. This prevents major temperature differences, and consequently it reduces the risk of condensation on the fruit. In addition, we also achieve energy savings by the resultant mixing of the hotter air higher the glasshouse with the colder air lower in the glasshouse. In fact, during sunny periods in spring we did not need to use the pipe heating at all. The sun heats the glasshouse up very quickly in the mornings. The aircobreeze fan then mixes the hotter air uniformly through the air in the glasshouse. In the summer the sun is very powerful, and the glasshouse heats up too

Controlling moisture

The Glasshouse climate theme day at Dings Aardbeien, Belfeld, on 7 November gave cause to two articles reviewing new insights into the optimisation of the glasshouse climate. A number of new techniques have been implemented in Marcel Dings' Airco glasshouse, including vertical ventilation with aircobreeze fans, high-pressure aerosols, and mechanical cooling. The glasshouse climate is monitored and analysed in detail. The resultant new insights can be of benefit to every glasshouse grower (including growers who do have the new techniques).
The vertical ventilation is focused on moisture control. The following article (in week 1 of next year) will review the effects and benefits of high-pressure aerosols, and will also explain why a higher relative humidity is beneficial in opening the leaves' stoma.

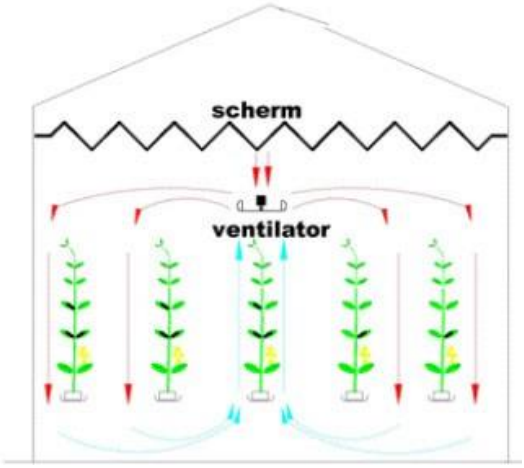
without heating

Various effects

Vertical ventilation has a number of effects:
Moisture control
- active climate without heating
- uniform evaporation due to optimum microclimate
- reduced risk of condensation
- makes increased use of screens feasible

Temperature control
- uniform temperature, both vertically *and* horizontally
- prevents cold draughts when screens are open
- reduced cooling of crop due to radiation as a result of the increased feasibility of screening
- lower pipe temperatures

Energy savings



The fan mixes the dry, cool air above the screen uniformly with the humid, warm air under the screen.

quickly. Then it is necessary to start heating the glasshouse to the day temperature early in the morning.
During the past year the fans were in operation almost all the time: they are turned off solely when the windows are more than 40% open. I expect a great deal from night-time humidity control based on the development in which unheated outdoor air is blown into the glasshouse. This, in combination with the Aircobreeze, will obviate the need for the minimum pipe temperature. At the moment the night-time use of the fans enables us to open up many fewer gaps in the screens. Since we are certain of an active climate I am now willing to make earlier use of the screens, which saves even more energy.

SAVING ENERGY

Aad Zuiderwijk, in Bergschenhoek, uses Aircobreeze fans in his gerbera glasshouses for safe energy conservation. “The air circulation around the plants greatly simplifies the prevention of diseases. I began using the fans this year. I estimate that I saved 5 cubic metres of gas last summer. Since the fans greatly reduce the risk of condensation on the plants while the glasshouse is being heated in the

One Aircobreeze fan per 200 square metres creates an air current of 5 centimetres per second – with a low power consumption of 1 Watt per square metre.

mornings I no longer need to heat the glasshouse as much as I used to. When I use the screens the temperature in the glasshouse is now much more uniform, and I no longer need to heat the glasshouse to discharge the moisture. In fact, I have the impression that the fans draw cool air through the screens, and obviously that’s highly beneficial during the use of the blackout screens in the summer. Now I’m using the lighting again, and the fans enable me to make much more efficient use of the heat emitted by the lamps by directing the hotter air downwards on to the crop. I can now set the pipes to a lower temperature.”

HIGHER RH DURING FLOWERING

Marcel Dings, a strawberry grower in Belfield, switches on the fans above the strawberries 1 hour after beginning to heat the glasshouse in the morning and leaves them on until sunset. “The fans prevent cold draughts when the screens are opened in the morning. We don’t use the aircobreeze fans at night, since high air humidities are not a problem with strawberries. The fans are switched off when the windows are opened more than 30% over day, since the natural convection in the glasshouse is the determining factor for the air circulation.
During the flowering period we endeavour to maintain an air humidity of between a maximum of 68 to 72 percent to achieve optimum pollination. However, since the aircobreezes create a more uniform and drier microclimate I have been able to work with air humidities of 75 to 80 percent. This has enabled me to limit the degree to which the windows are opened, resulting in a higher CO_2 concentration in the glasshouse. The higher RH has not had any detrimental effects on the pollination or fruit setting. The

VENTILATION

ENERGY SAVING

Vertical ventilation in semi-closed glasshouses

Air masses from the bottom

Grower Aad Zuiderwijk (left) explains to Jan Bontsema and Jan Voogt (right) that vertical ventilation offers him a number of benefits, such as a higher air humidity with an improved microclimate, energy savings, and an improved discharge of moisture through

Although vertical ventilation is not unknown outside glasshouse horticulture, the sector had no experience with the method until recently. This has changed since Wageningen UR Glastuinbouw (Wageningen University and Research Centre Glass Horticulture) and Hoogendoorn Growth Management began investigating the method. They are reviewing the opportunities offered by vertical ventilation, and these are certainly appealing:
an improved glasshouse climate, and energy savings. The current research has now been supplemented by two major practical trials that began in December. The Ministry of Agriculture, Nature and Food Quality

TEXT AND PHOTOS: JOS BEZEMER

It has long been known that a completely closed glasshouse (with the supply of heat to a non-closed department) is not profitable, and consequently does not offer a solution for many holdings. The energy consumption is too high, and the climate is not optimum. Semi-closed glasshouses would appear to offer more prospects. However, the necessary development work needs to be carried out on this type of glasshouse – as well as on the modified cultivation techniques that are required. “For this reason we emphatically raised the question ‘What does the plant want?’” says Jan Voogt, researcher and Hoogendoorn consultant. “Growers cultivating crops in a closed or semi-closed glasshouse will wish to achieve savings in the energy consumption and reduce CO_2 emissions, whilst the plants tell us that they appreciate higher temperatures, higher air humidities, and more CO_2. Photosynthesis then runs at full speed, and the plants achieve maximum output. It’s comparable to a car engine that has reached operating temperature, and then maintains a constant high efficiency.”

Excessively humid microclimate

Having established the above, the next question was the optimum air humidity. This is too low in many glasshouses: high levels of solar radiation can then cause drought stress, and output falls. “The knack lay in increasing the air humidity whilst avoiding detrimental effects such as condensation on the crop,” the project manager, WUR senior scientist Jan Bontsema explains.
Plants are, in particular, unable to cope with an excessively humid microclimate. This can be seen clearly in areas in which the sun or the lamps do not reach the plants, and when the screens are closed in the entire glasshouse. Botrytis can then be a problem with gerbera, whilst matricaria occasionally exhibits a loss of growing points. In fact, these or comparable problems are encountered with all crops. These have not yet been explained in sufficient detail in plant-physiological terms. However, they are certainly a risk, and growers need to try to avoid them.”

Thoroughly-mixed air layers

Vertical ventilation was found to offer a means of avoiding the disadvantages associated with high air humidities. Hoogendoorn installed four Airocbreeze fans at the holding of gerbera growers Aad and Nelleke Zuiderwijk in Bergschenhoek. This type of fan is suspended high above thecrop: the vane design ensures that the upper and lower air layers are mixed together.
“Ordinary fans are unable to do that,” Aad

to the top and vice versa

Zuiderwijk explains. “Almost all the air is displaced horizontally. You can create vertical air currents only by operating the fans at full power for a long time – and this costs a lot of energy, so you achieve virtually no savings. Smoke tests carried out with these fans have demonstrated that the air layers are mixed together thoroughly. That gave us reason enough to collaborate with further research.”

Energy savings

In spite of the modest scale of the trials (800 m^2), Aad Zuiderwijk nevertheless expects that vertical ventilation will lower the humidity and improve the climate. The technique also brought him energy savings. “Normally speaking, it’s necessary to increase the minimum pipe temperature to bring the plant to the required temperature and get the air in movement. Once the required temperature has been attained the windows have to be opened – and it’s bye-bye to the heat. Vertical ventilation avoids that, since you can mix the upper air warmed by the rising sun with the air lower in the glasshouse. And then you can leave the minimum pipe temperature for what it is.”

The appealing feature of this form of energy saving is the low energy input it requires. The fan’s motor consumes just 200 watts, whilst its radius of action is 200 m^2. Consequently vertical ventilation requires just 1 watt per m^2. With this consumption of 200 watts the fan is able to displace 6000 m^3 of air per 200 m^2 per hour.

Above and below the screen

The research also revealed a second effect: vertical ventilation achieves an excellent exchange of the air masses above and below the screen. Jan Voogt: “Crops in stationary air don’t do a lot. There is a risk of condensation, and the plants begin to sweat: they press, as it were, the surplus moisture out of the plants. Exchanges of air above and below the screen are possible solely with gaps in the screen, but this is difficult to control. Too narrow a gap has no effect, whilst gaps in excess of ten centimetres result in a chimney effect – and then it’s virtually inevitable that the plants will be exposed to cold draughts. With Aircobreeze fans the air can be brought into movement with a gap of just three centimetres – and then air circulates around the plants. Consequently this enables growers to get more grip on ventilation.”

The special design of the vanes results in the displacement of air masses from the bottom to the top, and vice versa.

Moreover, vertical ventilation can bring the heat emitted by assimilation lighting – as such, surplus heat – to the plants, thereby reducing the amount of direct heating required.

Various benefits

Gerbera grower Aad Zuiderwijk believes that vertical ventilation will offer him a number of benefits, namely an improved relative humidity with a better microclimate, energy savings by virtue of the reduced use of minimum pipe temperatures, improved moisture discharge via gaps in the screen, and energy savings achieved by the use of the surplus heat from assimilation lighting. In addition, his holding is offered a further benefit. He installed blackout screens last summer. “The screens are closed at seven o’clock in the evening. The vertical ventilation reduces the accumulation of moisture around the plants. Without vertical ventilation the air humidity would rapidly increase to ninety percent – and even higher around the plants. This hazardous situation is now avoided.”

The Zuiderwijk’s holding has 2.5 hectares of glasshouses: the results from the trial gave cause to the installation of vertical fans throughout the entire complex at the beginning of December – a total of 125 fans. “Our primary objective is to implement low-energy moisture control. You can’t achieve that in just a part of the glasshouse without partition walls. Consequently we decided, in consultation with Hoogendoorn and WUR Glastuinbouw, that the next step was to equip the entire glasshouse with these fans.”

Income and expenditure

The other practical trial is being carried at JB Matricaria in Venlo. WUR’s Jan Bontsema points out that a lot of research is already being carried out into ventilation. “We are investigating a wide range of opportunities, in particular for energy savings. The Aicobreese fan is highly compatible with the generic objective of this research.” The installation costs of these fans are still relatively high at the moment, due to the small numbers currently in use: however, these costs will fall once the fans are used on a larger scale. The investments

SUMMARY

Growers working with closed or semi-closed glasshouses use a higher temperature, higher CO_2 concentration, and higher air humidity. However, growers need to endeavour to avoid the disadvantages associated with higher air humidities. Aircobreeze vertical fans achieve excellent mixing of the upper and lower layers of air in the glasshouse. This results in an improved glasshouse climate, as well as energy savings achieved with low energy inputs. WUR Glastuinbouw has equipped the entire glasshouse of gerbera growers Aad and Nelleke Zuiderwijk with these fans for a

Reference list Greenhouse Nivolators
Various projects

amaryllis	L.G. Vreugdenhil & Zn	‘s-Gravenzande
bedding plants	Dutch Flower House	Beamsville (CA)
bedding plants	Elsner Pac Jungpflanzen Thierdorf GbR	Dresden
bedding plants	Gartneriet Møllerhøy	Odense (DK)
bedding plants	Martha Plant V.O.F.	Andijk
bedding plants	WPK Made (westlandse plantenkwekerij)	Made
bouvardia´s	Kwekerij Borgijink	Groessen
chrysanthemums	Dekker Chrysanten	Hensbroek
chrysanthemums	Dekker Chrysanten	Tanzania
cucumbers	Pecks Hill Nursery Ltd	Hoddesdon (UK)
cucumbers	Albuna Express Inc.	Leamington (CA)
cut flowers	Kwekerij S. Schouten BV	Wervershoof
flower bulbs	Bloembollenbedrijf Gebr. Ruijter	Slootdorp
freesias	P. Hofland B.V.	‘s-Gravenzande
freesias	Kwekerij K. Heeren Jzn	Aalsmeer
gerberas	Leamington Farmers´ Market!	Leamington (CA)
gerberas	Zuijderwijk & Witzier BV	Berschenhoek
gerberas	P.H. Kuivenhoven Green House	Otterville (CA)
herbs	Freeman Herbs	Beamsville (CA)
herbs	Hendriks Greenhouses	Beamsville (CA)
lettuce	Schippers Farms	Bow island (CA)
orchids	Levoplant	De Lier
orchids	Opti-Flor B.V.	Monster
orchids	W. & J. Valstar	‘s-Gravenzande
orchids	Ter Laak Orchideeën	Wateringen
orchids	Jamuflor BV	De Kwakel
potted lillys	Van Schie Potlelies	Honselersdijk
roses	Lindy’s	Beamsville (CA)
roses	BN Roses	De Lier
roses	Zuurbier & Co Premium Roses	Heerhugowaard
roses	R&R Roses	Maasland
seeds	Enza Zaden	Enkhuizen
seeds	Nunhems	’s-Gravenzande
seeds	Syngenta US	U.S.A.
seeds	Van Wijgerden Zaden	Bruchem
strawberry’s	Dings Aarbeien	Belfeld
strawberry’s	Schippers Farms	Bow island (CA)
tomatoes	Gull Valley Greenhouses	Bow island (CA)
tulips	Kwekerij Siem Munster	Slootdorp
tulips	Rainbow Colors B.V.	Andijk
vegetables	Bejo Zaden B.V.	Warmenhuizen

4. Installation advice - Nivolator