

Edition 2018 - 2019

*The
bright
side
of
growing*

ReduSystems[®]

www.redusystems.com

Second edition of the ReduSystems book!

Mardenkro invests a lot in the development and best use of ReduSystems products. This is the second edition, 2018 version, of the popular ReduSystems book. It consists of a selection of the most read articles from the ReduSystems newsletters of 2016 and 2017.

We like to share our knowledge and experience as we strongly believe this enables users worldwide to achieve the best growing results.

Thank you for your trust and interest in the ReduSystems products.

The Mardenkro team



ReduSystems: experience the bright side of growing

Radiation from the sun is the basis for all life on Earth. With ReduSystems products, Mardenkro specializes in adjusting solar radiation to the crop's needs in both glass and plastic greenhouses.

Our range of new products is constantly expanding, and the pace has been stepped up in recent years. Traditionally, we supply coatings to control the amount of solar radiation so as to minimize adverse effects on crops. But we can also make light more diffuse, guard against excess heat without affecting the light level, and influence the color of the light

transmitted. The next step is already underway: increasing the amount of light that can enter especially during the darker months. We want to offer added value during all season!

By regulating solar radiation with ReduSystems products in all seasons, growers have crop growth and develop-

ment at their fingertips. The possibilities are enormous: faster growth, higher yields, less stress, better product quality, longer flower stems, more compact growth, and lower water requirements.

A great deal of knowledge is required to make full use of all these possibilities: the knowledge to develop and further optimize our products, but also to apply them in the right way. We think it's important to share our knowledge with our customers so that you know what to expect, what the potential is and what the limits are.

Modern growers want to be at the cutting edge of production and to let as few opportunities as possible pass them by. It's therefore essential to have a good understanding of the processes that take place within the plant itself as

well as its reactions to the effects caused by our products.

This book provides an overview of technical information about ReduSystems products, light, user reviews, plant processes, and plant response to climate conditions. The continuous development of our products offers new tools for control. Knowledge of plant physiology and light is one of the essentials: only then can you achieve optimal results. As a valued customer we would like to offer you this useful gift. We hope you enjoy reading it!

The Mardenkro team



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Optimal climate in all seasons

The number of new products in the ReduSystems range has been growing rapidly in recent years. A cohesive system of solutions for all seasons is gradually taking shape. Mardenkro is thus becoming a year-round partner for improving the light and climate in the greenhouse.

Mardenkro started out as the producer of ReduSol. At that time – the late 1990s – the coating marked a great leap forward compared to traditional whitewash. It was a wear-resistant, solar reflective coating that was also easy to remove. Over the next few years, heat-resistant and diffuse coatings followed at a rapid pace. “They were all separate products at first,” says director Jort Gerritsen. “But we have invested a lot of R&D time in matching them to each other. The coatings must be able to be combined and they must enhance each other’s effect. That’s how ReduSystems came about: a cohesive system of coatings. It enables us to optimize the climate in the greenhouse by adjusting the incoming radiation. When you look at light and climate this way, you can see that there is a part of the year when you would want to increase light levels. We continued to develop along those lines.”

This has resulted in two new products. AntiCondens for Glass and AntiReflect.

“We are working on the development of a smart cleaning system.”

AntiCondens for Glass is a further development of Mardenkro’s existing product for plastic film greenhouses. Because the solution transforms the condensation on the glass into a film of water, it significantly improves the light level. Under the guidance of Mardenkro the launch of AntiReflect happened with trials at dozens of greenhouses. “This product is completely unique. It is the first AR solution you can apply to an existing greenhouse. All other AR solutions are applied when the glass is produced in the factory,” says Gerritsen.

Because AntiReflect changes the refractive index of light at the interface of air and glass, more light enters the greenhouse. That is very welcome in periods with low levels of natural light, when every percent more light translates into profit.

Solutions for the whole year

“Going forward, we intend to continue on this path of devising solutions for the whole year. Our wide product range en-



Jort Gerritsen
CEO Mardenkro

ables us to work with growers to come up with a tailor-made climate strategy or light plan in which the coatings are an important tool,” he says.

There is now an effective combination of solutions available for all the climatic conditions in the world. For the summer there are light- and heat-resistant coatings, where possible combined with diffuse coatings that also do a useful job in spring and autumn. In autumn and winter, the important thing is to increase light transmission. Besides AntiCondens and AntiReflect, another criterion is keeping the glass clean all year round. Gerritsen again: “We are working on the development of smart cleaning solutions. Current cleaning products work well but are so aggressive that their use is frowned on socially. Mardenkro not only develops solutions for easier, user-friendly cleaning; we are also looking at anti-soiling solutions. These are solutions that prevent contamination throughout the year. We plan to move in that direction over the next few years. The technology offers good opportunities for this.”

Measuring light

Another development for the future is remote advice and control based on locally measured data. For this purpose, Mardenkro is working with a technical university to develop their own light measuring system. The system will consist of a series of highly accurate measuring units which permanently measure the light over a large area under the greenhouse roof. Advanced software then analyses the data. The system is to be trialled at the first growers to use AntiReflect. The results will confirm how much light gain the product provides in practice in their greenhouses. Gerritsen: “If you combine current data on measured light with weather forecasts and data on the crop, you can determine whether to apply coatings, or combinations of coatings, or whether it is time to remove them. Responding properly to the circumstances can significantly improve the quality of the crop and the product. With this technology, we will in time be able to offer remote support anywhere in the world.”

Removable coatings to optimize greenhouse climate

ReduSystems coatings are sprayed onto greenhouse roofs and are weather-resistant for the entire season. ReduSystems coatings can be removed at any time with ReduClean.

As no two situations are the same, ReduSystems coatings prides itself on providing growers anywhere in the world with the solution they need.

ReduSystems coatings consists of three product lines:

SHADING

Effective protection against excess heat and/or light

Coatings that lower crop and greenhouse temperatures by reflecting heat-generating infrared light. The amount of grow-light that is transmitted depends on the choice of product.

DIFFUSION

Maximum light diffusion with minimum grow-light loss

Coatings that allow maximum sunlight diffusion, while maintaining high levels of grow-light transmission. The amount of heat radiation (infrared) that is reflected depends on the choice of product.

SPECIALTIES

Crop specific coatings

In the Mardenkro laboratory, new products are continuously developed in association with leading international research institutes, universities and growers. The specialities group consist of coatings designed for specific crops or climatic conditions. It also includes innovations that are to be tested further for efficacy in various crops.

ReduSol®

A practical and versatile shading agent



What is ReduSol?

ReduSol is a shading agent that reflects high levels of solar energy. It is wear-resistant and can be easily removed with ReduClean. For many years ReduSol is the obvious choice for protecting crops against excess heat and light.

Properties

- Best price-quality ratio on the market
- Up to 80% shading
- Wear and frost resistant
- Higher light transmission during rainfall
- Flexible in use, easily combined with other ReduSystems products
- Suitable for glass, acrylate, polycarbonate and plastic film
- Easy to remove with ReduClean

Application

ReduSol is a versatile shading agent that can be used in many different situations. Depending on the climate, both light-preferring and shade-preferring crops can benefit from a coating of ReduSol.

ReduHeat®

High grow-light transmission and effective heat reflection



What is ReduHeat?

ReduHeat is a protective agent containing a special pigment that transmits grow-light (PAR) while reflecting most of the heat radiation.

Properties

- High levels of grow-light (PAR) transmission
- High reflection of heat radiation (infrared)
- A better climate due to lower ventilation requirements
- An evenly balanced climate without peaks
- Suitable for glass, acrylate, polycarbonate and plastic film
- Highly wear-resistant
- More comfortable work conditions
- Easy to remove with ReduClean

Application

ReduHeat provides an optimal balance of light and temperature. It is suitable for crops that thrive on large amounts of light but need protection against heat.

ReduFuse®

The most flexible solution for light diffusion



What is ReduFuse?

ReduFuse is a coating that diffuses the light when it enters the greenhouse. Diffused light penetrates deeper into the crop and can improve production and quality.

Properties

- Very high light transmission
- An evenly balanced climate due to light diffusion
- Less stress in the crop
- More photosynthesis, also in the lower leaves
- Lower leaf temperature
- Transparent during rainfall
- Highly wear-resistant
- More comfortable work conditions
- Only to be applied on glass roofs

Application

ReduFuse is suitable for all crops that need large amounts of light. Shading is minimal so there is no protection against heat radiation. ReduFuse has proven successful when applied to vegetable crops and highly light-dependent flowers and plants.

ReduFuse® IR

Optimal diffusion combined with heat reflection



What is ReduFuse IR?

ReduFuse IR is a coating that reduces heat radiation while diffusing the light when it enters the greenhouse.

Properties

- High light transmission (PAR)
- High reflection of heat radiation (infrared)
- An evenly balanced climate due to light diffusion
- Less stress in the crop
- More photosynthesis, also in the lower leaves
- Lower leaf temperatures
- Highly wear-resistant
- Easy to remove with ReduClean
- More comfortable work conditions
- Suitable for glass, acrylate, polycarbonate and plastic film

Application

ReduFuse IR is suitable for all crops that are heavily dependent on light and has proven successful when applied to flowers, plants and vegetables in warm climates and during warm periods. ReduFuse IR is ideal for crops that thrive on diffused light but cannot stand too much heat.

ReduFlex® BLUE

A photo-selective coating reducing mainly blue light and infrared



What is ReduFlex Blue?

ReduFlex Blue is a photo-selective coating which has a beneficial effect on the cultivation and production of cut roses because it transmits relatively less blue light than red light. It also reflects high levels of infrared radiation (heat).

Properties

- Prevents high plant and bud temperatures by reflecting a larger amount of high-energy blue light
- Lowers greenhouse temperatures through high reflection of infrared radiation
- Pushes up production due to relatively higher levels of red light
- Highly wear-resistant
- Suitable for glass, acrylate, polycarbonate and plastic film
- Easy to remove with ReduClean

Application

ReduFlex Blue improves photosynthesis by allowing crops to reap optimal benefits from relatively high amounts of red light. At the same time it lowers the greenhouse and plant temperatures by more reflection of high-energy blue light and infrared radiation.

ReduFlex® GREEN

A photo-selective coating reducing mainly green light and infrared



What is ReduFlex Green?

ReduFlex Green is a photo-selective coating that reduces the levels of green and yellow light in greenhouses. It substantially reflects this part of the grow-light that some crops use less efficiently for photosynthesis. Reflecting the excess energy in the grow-light and the infrared radiation reduces greenhouse temperatures.

Properties

- High reflection of green and yellow light
- Lowers greenhouse temperature through high reflection of infrared radiation
- Relatively more radiation from blue and red light
- Lower plant and greenhouse temperatures
- Highly wear-resistant
- Suitable for glass, acrylate, polycarbonate and plastic film
- Easy to remove with ReduClean

Application

ReduFlex Green improves photosynthesis by allowing crops to reap optimal benefits from relatively high amounts of blue and red light. At the same time it lowers the greenhouse and plant temperatures by more reflection of green light and infrared radiation.

Solutions to increase light transmission

During autumn and winter, light is the limiting factor for plant growth. So every percentage of extra light entering the greenhouse during this period results in extra production.

Mardenkro also offers solutions to help growers get the most out of the available light at these times of year. The three products that can help increase production are AntiReflect, AntiCondens and GS-4.

AntiReflect reduces the reflection of light, allowing more light to reach the crop, while AntiCondens prevents light-blocking water droplets from forming on the inside of the greenhouse roof. Finally, GS-4 makes the glass sparkly clean without roughening the surface and contains no harmful fluoride gases.

AntiReflect

Anti-reflection solution for existing glass greenhouses



What is AntiReflect?

AntiReflect is the first and only retro-fit anti-reflection solution for existing glass greenhouses to increase light transmission. A large part of the year, light is the limiting factor for production under glass. More light is therefore very welcome. AntiReflect improves light transmission by reducing reflection, so more light is available for the crop.

Applying AntiReflect will increase transmission with approximately 3% (measured hemispherical by Wageningen University (WUR)). AntiReflect is developed to be fully compatible with other ReduSystems coatings and ReduClean.

Properties

- Approximately 3% more light in the greenhouse
- Ready-to-use: no mixing needed
- Developed to be compatible with other ReduSystems coatings and ReduClean.
- Very wear resistant

Application

AntiReflect should always be applied by a trained operator of a computer controlled spraying machine. Always consult Mardenkro for information before application. The solution is supplied as a ready-to-use product.

AntiCondens

Anti-condensation solution preventing droplets in glass and plastic greenhouses



What is AntiCondens?

AntiCondens creates a hydrophilic layer that causes condensation to run off the surface thus preventing the formation of water droplets. This will provide up to 5% additional light and prevents damage and diseases.

Properties

- Available in two versions, to apply on glass or plastic foil
- Water-based and safe to use
- Easily mixed in water
- Very wear resistant, lasts the entire season

Application

AntiCondens should be applied on a clean, dry surface, free of other substances. Apply AntiCondens in fast drying circumstances by spraying from the gutter to the top of the ridge until the surface is entirely moistened.

After application, allow the treated surface to dry thoroughly. If applied well, AntiCondens will remain active the entire season.

GS-4

Cleaning solution for greenhouse glass



What is GS-4?

Grow-light is critical to your crop. Clean, clear glass will transmit more grow-light into the greenhouse. Regular cleaning is a necessity. GS-4 is a glass cleaner developed specifically for horticultural greenhouse glass. It removes dirt such as soot, dust, rust and algae.

Properties

- Suitable for use on both the inside and the outside of the greenhouse
- Will not roughen the glass
- Contains no hydrogen fluoride gases and is therefore safer for humans and for the environment

Application

Apply GS-4 to the glass by misting. Allow the product to act and then rinse with generous amounts of water. Never let the product dry on the glass.

Custom advice tailored to crop, climate and region

Greenhouse horticulture is booming worldwide. To ensure that customers are properly advised about the right product, the Mardenkro sales team is being expanded. After all, the growing and climate conditions vary from place to place.

Russia wants to be self-sufficient in vegetables within five years, with particular focus on tomatoes. This policy has resulted in a sharp increase in high-tech horticulture. The greenhouse production area is also growing in other CIS countries (the former Soviet Union). There has been an upsurge in floriculture in Central and South America, while indoor vegetable production is steadily gaining ground in Asia in response to rising demand for quality produce.

The Mardenkro sales team is actively pursuing these opportunities. "We believe it's important to speak the grower's language and be able to give specific advice, anywhere in the world," says Commercial Manager Barry Zuidgeest. The team has now been strengthened by the addition of Firuza Ruzikulova in Russia and Yosef Giles in Mexico. German-speaking areas are also being given higher priority. Zuidgeest: "And to ensure we reach growers and educate them more about the influence of light, we're attending even more trade fairs around the world and now publish our popular newsletters in several languages, including Russian."

Year-round

ReduSol is the product that is most in demand globally, but it is interesting to note the growing interest in specialties. Zuidgeest again: "ReduFlex Blue

is popular with rose growers in Africa and Latin America because the coating has the ability to increase stem length. And at the request of a grower in South America, we developed ReduFlex UV, which blocks UV rays in plastic greenhouses. This prevents blackening of the rose buds, eliminating the need to cover each bud with netting. So the coating actually cuts down the amount of work required. The cost of labor is on an upward trend in horticultural areas everywhere so you can no longer solve quality issues by bringing in more people. At Mardenkro we support growers by increasingly seeking climate-specific solutions."

"As our product range grew, we were able to start advising on improving light distribution in the greenhouse."

The number of ReduSystems products is now so large that companies can be supplied with a custom coating all year round. That goes for countries with distinct seasons as well as for equatorial countries with a fairly constant climate.



Roger de Jagher

Barry Zuidgeest

Paul van Gils

Peter Heemskerck

Firuza Ruzikulova

Yosef Giles

Jelle Hoogland

The new solution AntiCondens for Glass, for example, can be used whenever condensation is a factor: in regions with a moderate climate, in Mediterranean countries, but also in countries like Australia and New Zealand. The solution distributes condensation as a thin film over the greenhouse roof, allowing more light in. "We used to visit growers just to talk about light reflection," says Zuidgeest. "As our product range grew, we were able to start advising on improving light distribution in the greenhouse. Now we can even help them bring in more light. We give growers a set of tools to enable them to constantly adjust the light to their requirements."

Combine different coatings

One emerging trend is to use combinations of coatings. Zuidgeest gives a practical example: "In spring, apply ReduFuse to diffuse and soften the light. Then in summer ReduSol to reflect high levels of solar energy. Once summer is over, partly wash it off and then clean it off properly a couple of weeks later. In the autumn, apply AntiCondens and later AntiReflect to maximize light. This system works because all of our coatings are fully compatible."

Light plan

More and more growers are asking for a light plan tailored to their specific situation. "We've done that for a greenhouse in Vietnam, for instance," the commercial manager explains. "In the past they used only ReduSol. Now we've divided up the year into phases and looked at

when there is too much light and when the light just needs to be made a little softer. The result is a schedule that involves successive use of ReduFuse and ReduSol, including application and removal times. We've also made coating recommendations to growers in Australia, based on their growing plan and light figures. And in Austria we've advised a customer to use ReduFuse and also SprayChalk mixed with ReduSol for a limited period. The rain washes it off gradually and it provides just the right degree of protection."

Growers who would like a customized light plan should contact the ReduSystems account manager for their region.

Mardenkro shares its expertise with users and crop consultants. The newsletter with informative articles about light and plant physiology has a global mailing list. Distributors and consultants receive regular updates on how the different coatings work and the options for controlling light in the greenhouse.

"Mardenkro shares its expertise with users and crop consultants."

Zuidgeest sums up: "The market is becoming increasingly critical. Anyone can find vast amounts of information online about their crops and about possible ways of influencing light transmission.

Mardenkro is committed to having each and every one of its products extensively tested by independent bodies before placing them on the market. This ensures that the products perform well and that there are no surprises."

Give custom advice with ReduWizard

KNOW-HOW More and more growers consider applying a coating on the greenhouse roof. They are able to choose from a large number of ReduSystems coatings. Various issues would then have to be taken into consideration. ReduWizard will make the choice easier.

2. Crop

- Hydrangea (cut flower)
- Hydrangea (pot plant)
- Kalanchoe
- Lily
- Matthiola (cut flower)
- Pelargonium
- Peony
- Perennials
- Phalaenopsis
- Pot plant (evergreen)
- Pot plant (flowering others)
- Ranunculus (cut flower)
- Rose (cut flower, mixed)
- Rose (cut flower, red)
- ✓ Rose (cut flower, white)
- Rose (pot plant)
- Spathiphyllum
- Strelitzia (cut flower)
- Tulip
- Waterplants

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The cal

View recommendation

ADVICE 1		ADVICE 2	
			
Apply			
April		April	
Remove with ReduClean			
September		August	
Buckets per hectare			
18		21	
Suitable for			

To choose the right coating for a crop and to determine the optimum dosage, not only the plant and the location need to be taken into consideration, but also the variety, the type of greenhouse, the existing screens and possible other cooling options. All these factors are closely linked and therefore make the decision difficult.

With the ReduWizard you can compile

a custom solution for over 50 types of ornamental crops and almost 20 vegetable crops. The tool can be used globally thanks to the link to a database of climate data from 3,000 locations (temperature, solar radiation and precipitation). Based on a smart calculation model, the ReduWizard generates practical advice for the grower.

Prompt advice for coating

To prepare the correct advice for a particular crop, the location, the crop, the greenhouse characteristics and the acreage must be entered successively in the ReduWizard. Based on this input, the tool generates the advice with a selection of the most suitable ReduSystems product for the particular crop and the location. For some situations the ReduWizard generates two opinions. Depending on the values presented by the ReduWizard, presented in two tables next to each other, a decision can be made in consultation with the grower. After the decision has been made for one of the coatings, a more in-depth advice can then be requested for the chosen product. This advice states the best time to apply the coating, the dosage and the best time to remove it. You can receive this ReduWizard advice in your mailbox.

ReduSystems coating

Greenhouse temperature, light intensity, diffusivity and light colour play important roles in enhancing the quality of ornamental plants. A ReduSystems coating on the greenhouse roof can influence these climate factors to such an extent that a better greenhouse climate is created. This can result in better flower colour, a more compact crop or the opposite, increases stem length. The employees in the greenhouse will also have a more pleasant working environment.

Get your personalized advice at: reduwizard.com



INCREASING TRANSMISSION



Solutions to increase light transmission

For a part of the year, light is the limiting factor for plant growth. So every percentage of extra light entering the greenhouse results in extra production. In recent years we have been specifically focusing on improving light transmission. This has resulted in a whole new range of unique solutions.

How does AntiReflect work?

KNOW-HOW AntiReflect reduces the difference in refractive index between air and glass; that is why the greenhouse receives more light.

Light rays change direction when they enter one medium (glass) from another medium (air). The extent to which they change direction is determined by the refractive index of the material. The refractive index is also the determining factor for the reflection on the material. The more the refractive index of two materials differs, the more reflection. The refractive index of air amounts to approximately 1, that of glass to 1.5. Using a certain formula, the Fresnel equations, it can be calculated that in that case more than 4% of incident light is reflected. This occurs again when the light exits on the other side of the glass.

AntiReflect reduces the refractive index to approximately 1.3. Consequently, there is less reflection and more light enters the greenhouse. It would be even better to apply on the inside of the greenhouse also, which will also reduce the reflection there. However, practically, this is not yet possible.

Measuring hemispherical light transmission

When light falls onto a greenhouse roof, glass or plastic, three things always happen. A large part goes straight

through the glass or plastic, which is known as the transmission. Part of the light reflects on the roof; that is the reflection. The third part is called absorption: this is the solar radiation that penetrates the material, but does not come out on the other side. This absorption causes the glass or the plastic to warm up. Together, transmission, reflection and absorption always lead to 100% of the solar radiation.

When light falls perpendicular to a glass roof, 90% goes through it. But not all

the light falls perpendicular to the glass: a large part comes from another angle. That is why the transmission should always be measured hemispherically (from all angles) in order to get a clear picture of the actual transmission. The lower the angle of incidence, the lower the transmission and the higher the reflection. In countries in North-West Europe the light in winter falls at a lower angle, making the reflection significant.

Light gain

AntiReflect reduces the reflection of all angles of incidence by approximately 3%. Measurements taken at the LightLab at Wageningen University & Research show that light gain with this solution is the highest at an angle of 60°. This angle of incidence is particularly common in North-West Europe and Canada.

Antireflection layers are used in many industries, but the techniques are not easily translated into greenhouse applications. The first condition is that reducing the reflection must not be at the expense of the transmission as this would evaporate part of the light gain. The second condition for the development of this solution is that it has no impact on the ratio of the colours of the light spectrum. The transmission gain across the entire light spectrum is the same. AntiReflect is based on nanotechnology and is derived from techniques that are used in solar cells and in space technology, among others. This revolutionary solution is the result of years of research and development.



Is AntiReflect invisible?
See for yourself in this video.
[Antireflect.com/video](https://www.antireflect.com/video)



Calculation model accurately predicts increased production with AntiReflect

KNOW-HOW An increasing number of ornamental crop growers regularly measure the amount of light in the greenhouse. But just as important as the light level at any given time is the total light sum or daily light integral (DLI) received by the crop.

In advance of practical trials, Wageningen UR has calculated the extent to which production increases under AntiReflect. The outcomes are very much in line with early practical results.

When developing new products, it is important to be able to quickly estimate the benefits for the grower. Mardenkro greatly values the results of independent assessments and, as standard practice, has all new products analyzed by the LightLab of the Greenhouse Horticulture Business Unit at Wageningen University & Research in The Netherlands. This provides an accurate picture of their physical properties. After that, the question is how the crop will perform under a new product. Model calculations can predict performance well and produce results much faster than practical trials.

Once the new AntiReflect solution was ready for use in practice, Wageningen

UR calculated the effect it would have using the Intkam crop model. The practical trials, which have been running since 2015, confirm the outcomes.

Photosynthesis and growth

"Intkam is a calculation model that calculates growth, development and production of greenhouse crops. We have been using models since the 1970s and we have been constantly refining them. So we can now say that we have built up decades of knowledge," researcher Anne Elings explains. "At the heart of the model are the photosynthesis, respiration and development rate calculations. The outcomes of these calculations are translated into growth and production."

Some processes are the same in all crops, such as photosynthesis, while others are crop-specific, such as leaf,



flower and fruit formation. The researchers enter the crop, the cultivation strategy and the climate details into the computer model. To achieve reliable results, good crop knowledge is essential. Intkam now works well for tomato, cucumber, sweet pepper, rose, gerbera and chrysanthemum.

"Mardenkro greatly values independent assessments and has all new products analyzed in the LightLab."

Using extra light

Light that falls on the greenhouse roof can pass through the glass (transmission) or it can be absorbed or reflected. The AntiReflect solution reduces reflection so that more light is transmitted through to the crop. According to measurements in the LightLab, the light gain is 3% to 4% in all seasons.

To calculate what the crop can do with that extra light, you first have to know what effect it has on the greenhouse climate. This is calculated with another model: Kaspro. "Our colleague Frank Kempkes calculated the effect of AntiReflect by the hour for a whole year based on data on the outdoor climate

and the characteristics of the greenhouse. This resulted in a light profile for the year, consisting of diffuse and direct light, PAR (photo synthetically active radiation), NIR (near infrared thermal radiation) and UV radiation," he says.

This light profile and the climate data were entered in Intkam to calculate photosynthesis at different heights in the crop for every hour of the light period. The results were added to the photosynthesis for the entire crop. "This gives you a certain amount of growth per day. The next question is how the plant distributes the assimilates among its organs. This calls for in-depth knowledge of the crop, and we have built this up over the years," says Elings. In practice, model calculations often need to be fine-tuned for different greenhouses because every grower grows in a slightly different way. "It therefore helps to give the increase in production in percentages. For example, production of a standard crop of tomatoes under AntiReflect is 3.2% higher than without, and 3.4% for chrysanthemums," he says.

Extra light welcome in winter

Extra light makes more difference if the light level is not very high to begin with, such as in the winter months. This mainly has to do with the way photosynthesis works. Photosynthesis increases rapidly as light levels increase but it plateaus once the intensity reaches a higher level. Every percent of additional light makes a big difference in the upward phase, but it has less effect in the level phase. "That is also the reason why roses perform less well than

chrysanthemums under AntiReflect, with a production increase of just 2.8%. We based our calculations for roses on a higher level of assimilation lighting. Extra light doesn't make that much difference in that case," the researcher explains. On the other hand, the rose mainly sends the additional assimilates obtained from the extra light to the harvestable parts. That balances out the difference.

The highest increase achieved under AntiReflect is in cucumbers, at 5.1%. This is because the extra assimilates go mainly to the fruits. The two other crops calculated with Intkam were sweet pepper and gerbera, with increases in production of 2.9% and 2.6% respectively. Elings: "The more light there is, whether it is natural or assimilation light, the greater the effect of AntiReflect will be. Combating reflection also seems to help at higher light levels, when photosynthesis plateaus. The increase in production is achieved in almost all months."

"The more light there is, whether it is natural or assimilation light, the greater the effect of AntiReflect will be."

Practical tests confirm higher production under AntiReflect

KNOW-HOW The first growers to use the new AntiReflect solution are seeing higher production as more light is entering their greenhouses. AntiReflect is being launched commercially this year.

After many years of development and testing, Mardenkro launched its revolutionary solution which reduces reflection off the greenhouse roof in 2017. This new product brings approximately 3% more light into the greenhouse all year round. The solution can be applied to any existing glass greenhouse, thus putting antireflection within reach of every grower.

More light converted into more production

Prior to the launch, several growers tested the solution at their greenhouses last winter and spring. These practical tests confirm the increase in production, model calculations by Wageningen University & Research (WUR) reveal.

Using the Intkam crop model, the WUR researchers measured how well vegetable and ornamental crops were able to convert the additional incoming light into production. The result in tomato (standard cultivation) and sweet pepper was an increase of around 3%, with more than 5% in cucumber (2 crops

per year). Production in rose and gerbera was up by more than 2.5% and by more than 3% in chrysanthemum. The calculations in ornamental crops took account of the assimilation lighting used.

Effective in all seasons

A proportion of sunlight is lost due to reflection off a greenhouse roof with standard glass and therefore cannot be converted into production. This reflection can be prevented with AR glass, but that is only an option in a new build. For existing glass greenhouses, AntiReflect works just as well - in fact, the solution scores even better in some respects. It is dirt-repellent, so less dirt adheres to the coated greenhouse roof than to standard glass. This feature can boost light gain in the greenhouse. In the LightLab at WUR, measurements and calculations were performed using the Raypro model to determine transmission at all angles of incidence. This is important because every additional percent of light counts in the darker months, when the sun shines



Five percent more cucumbers under anti-reflection solution!

KNOW-HOW Applying AntiReflect increases the yield of cucumbers by more than five percent. Calculations by researchers at Wageningen UR Greenhouse Horticulture clearly shows this.

at a low angle for most of the day. According to this research, transmission is approximately 3 percent higher than on uncoated glass over a large trajectory - from 0° to around 70°. The researchers concluded that the light gain is constant in all months. Besides PAR light, transmission of infrared light also increases, albeit to a lesser extent.

ReduSystems products can be combined

AntiReflect can be left on the greenhouse roof throughout the year and lasts for at least a year. Coatings such as ReduFuse and ReduHeat can be applied on top with no performance loss. When these coatings are removed at the end of the season, the AR function of the product underneath remains intact.

Precise application is key

The amount of transmission depends mainly on the thickness of the layer.

So Mardenkro has liaised with contractors to produce work instructions for applying a very even layer on a clean greenhouse roof. This can only be done mechanically. Some of these companies were involved in the trial phase and are fully aware of the level of care required, while others will have to carry out tests themselves to achieve the best result.

AntiReflect is only available as a ready-to-use formulation, so it is impossible to get the dose wrong.

To avoid damaging the layer, no fluoride-based cleaning products should be used on it. When removing a coating applied on top (such as ReduFuse or ReduHeat) with ReduClean, it is important to allow it to be washed off by rain and not to immediately remove it with a roof washer.

Exercising care at all times will ensure an effective solution that performs well and generates gains for the grower throughout the year.

The production of all fruit crops under AntiReflect increases compared to untreated glass, but with cucumber the increase is downright spectacular. The yield increase is even higher than can be expected on the basis of the absorbed light. Wageningen researchers have calculated, using the crop growth model 'Intkam', how a cucumber crop behaves under the new revolutionary solution. Their calculations are based on two crops per year. The first is planted on January 21 and ends on June 13. The second is planted on June 17 and ended on October 31st. This results in a total cultivation period of 9.3 months. The plant density was 1.5 plants per m².

Dividing of assimilations

Just like tomato and pepper the amount of light that the crop absorbs was roughly 3% higher under AntiReflect compared to standard greenhouse glass. Also, the increase of the photosynthesis is similar to the other two fruit vegetables, namely 3.1%.

Cucumber behaves very differently

however when it comes to the distribution of those extra assimilates; it sends more to the fruit.

Remarkably, the leaf area remains the same under more light. So the grower doesn't need to take any additional measures in this area. The plant weight increases by 2.2%.



Amazing is the amount of extra weight to the fresh cucumber. That is no less than 5.1%! For cucumber growers there is every reason to look forward to AntiReflect.

Visit antireflect.com for the latest news and results



Rose makes excellent use of extra incoming light

KNOW-HOW AntiReflect solution provides approximately 3% more outdoor light in a greenhouse with roses under growlights. Photosynthesis does not increase as much in relative terms in rose as in other ornamental crops, but the crop is able to send the extra assimilates it produces to the right place, in other words to the stem and the flower. This boosts yields by 2.8%.

Researchers at Wageningen UR Greenhouse Horticulture compared two situations: a greenhouse roof treated with

AntiReflect and an untreated greenhouse roof. To do this they used the Intkam crop growth model, which over

the years has been able to simulate the situation in the greenhouse very closely. The plant density was 7.5 plants/m².

In addition to rose, the researchers also looked at chrysanthemum and gerbera. The use of AntiReflect increases natural light in the greenhouse by approximately 3%. In their calculations in Intkam, they used a light intensity of 189 $\mu\text{mol}/\text{m}^2/\text{s}$ from the artificial lights.

So it is no surprise that the increase in photosynthesis is 1.5% lower compared to these two ornamental crops, as it is harder to realize even more photosynthesis if the crop is already exposed to very high light levels.

Sugars mainly to stem and flower
But what is surprising is what the rose does with the extra assimilates. The leaf surface area and plant weight increase by 1.3% and 1.2% respectively. In contrast, the harvestable part - the stem plus the flower - fares much better at 2.8%. So rose even outperforms gerbera in that area.

AntiReflect reduces reflection of the greenhouse roof and has the strongest relative effect at lower light levels. This is because the light response curve shows an ascending line that tails off at higher levels. So the more light there already is, the less gain there will be from the extra light. But there is a definite light gain for rose in the winter months, when every last bit of natural light entering is very welcome. And that immediately translates into extra production, as the calculations irrefutably show.

“AntiReflect reduces reflection of the greenhouse roof and has the strongest relative effect at lower light levels.”



Light-loving sweet peppers benefit from new solution

KNOW-HOW Sweet peppers belong to the light-loving plants. If the climate is managed well it would take a lot of light before problems occur. Especially in the winter months and at the start of the day higher light levels in the greenhouse would be very welcome. Calculations show that AntiReflect appears to provide a yield increase of 2.9%.

The calculations were carried out by researchers from Wageningen UR Greenhouse Horticulture. They have made use of the "Intkam" crop growth model, which is refined over time on the basis of practical tests and therefore well capable to simulate a practical situation. The researchers based their calculations on a planting date of December 1 and an end date of October 31st. In other words, a production period of 11 months. The plant density was 2.25 plants per m².

"The most important to the grower is the amount of yield increase."

They have compared two situations: a greenhouse treated with AntiReflect and an untreated greenhouse. In their comparison they have included previous data about AntiReflect, measured by LightLab Wageningen UR. All other

factors remained the same. The crop model then calculated photosynthesis, respiration, evaporation, growth and development of crop and fruit.

Additional sugars

AntiReflect reduces reflection on the greenhouse roof, thus providing a higher light level. As a result, the photosynthesis of sweet peppers rises by 3%. The question is what happens to the extra produced sugars. It turns out that the total plant weight increases by 1.6%, and the leaf area by 0.2%. The most important to the grower is the amount of yield increase. This appears to be 2.9%.

This extra yield means the pepper growers might have additional cost for labor, marketing, CO₂ dosage and the obvious cost of purchasing the AntiReflect and its application. However, the extra revenue certainly outweighs these additional costs.



New solution boosts gerbera production

KNOW-HOW The new AntiReflect solution can increase gerbera yields by 2.6%. The impact of the higher light incidence grows throughout the year, enabling growers to harvest more kilograms of flowers.

Reflection off the greenhouse glass means that some of the natural light doesn't reach the crop and therefore can't be used for photosynthesis. AntiReflect reduces this reflection and increases transmittance through the glass by about 3%.

To calculate this, the researchers used the Intkam crop growth model to simulate a gerbera crop that is in the greenhouse the whole year. The crop had a density of 6.2 plants per m² and was compared in two situations: an untreated greenhouse roof and a greenhouse roof treated with AntiReflect. They also took into account the artificial lighting with a light intensity of 100 $\mu\text{mol}/\text{m}^2/\text{s}$.

Over the years, the Intkam model has been found to reflect the situation in the greenhouse very accurately. It calculates the following plant processes in their context: photosynthesis, respiration, total crop growth, organ growth, development, transpiration and the strength with which the sinks (all the growing parts that need assimilates) attract the sugars produced.

Extra sugars

The calculations show that photosynthesis is 2.6% higher under the AR solution because of the increased light. That leaves the question as to where the extra sugars produced go, since in gerbera only a very small part of the plant is harvested. The total surface area of the leaf in the greenhouse doesn't grow at all, but the plant weight increases by 2.6% and the total production of flow-

ers increases by the same percentage. It can therefore be concluded that the plant distributes the extra sugars evenly over the different parts of the crop.

“The calculations show that photosynthesis is 2.6% higher under the AR solution because of the increased light.”





Substantial light gain in all seasons

KNOW-HOW AntiReflect offers light gain of approximately 3% in all seasons. This is the result of calculations by Wageningen UR Greenhouse Horticulture with the Raypro model. Especially in the poor light periods a few percent of extra light can make a world of difference.

AntiReflect offers light gain of approximately 3% in all seasons. This is the result of calculations by Wageningen UR Greenhouse Horticulture with the Raypro model. Especially in the poor light periods a few percent of extra light can make a world of difference.

The Raypro model is based on "ray tracing", a method where a light beam is being followed from the source through the material. The result is visualised in 3D. Based on this method, transmission, reflection and absorption from the sun-beam through the material can be calculated. Researchers of the LightLab of Wageningen UR first defined the transmission per angle of incidence. Over a wide range, from 0 to about 70 degrees it turns that glass with AntiReflect consistently transmits 3 to 4% more light than the widely used uncoated glass.

Model greenhouse

This data is then used for the ray tracing. To do this it is first necessary to define the greenhouse. Researchers have taken a Venlo greenhouse with a roof slope of 23 degrees and a 4 meter wide peak, with the usual structural elements, all of which play a role for the light which

ultimately could benefit the crop. Subsequently, in order to do the calculations, it was necessary to run the ray tracing model for each hour of the year, for both greenhouses, one with AntiReflect and one untreated.

Direct and diffuse light

The incoming light consists of direct and diffuse (= hemispheric) light. With direct light the angle of incidence is important, with diffuse light it is not. For each country the position of the sun for every day of the year is a known fact and therefore the angle of incidence of direct light. Since the ratio between direct and hemispheric light throughout the year can be different every day the long-term average is taken. The underlying computer models and calculations are ingenious. The outcome of the calculations however is surprisingly simple; in any season the light gain in the greenhouse is the same. This result however is not so surprising because the measured gain over a large part of the angles of incidence is very stable.



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Extra light by cleaning the glass

KNOW-HOW Over the years different innovations have been introduced to obtain more light in the greenhouse. White coated pillars, larger panes of glass and narrower gutters all help to ensure that more light falls onto the crop. But to make the most of this extra light, don't forget to clean the glass.

Slightly dirty glass due to dust or algae can quickly result in a few percent less light. Algae, dust, and soot from the boiler or cogenerator are common pollutants on glass. But inorganic dirt too hinders light penetration. Inorganic dirt consists of residue from fertilisers and crop protection products. Cleaning the glass is a simple and cheap solution to getting more light into the greenhouse again. Also, fungi and viruses have less chance of clinging to the dirt.

“Hygiene protocols and viral pressure require growers to thoroughly clean the greenhouse.”

Big clean-up

For many growers autumn is the time to change over to the next crop. Often this includes a thorough cleaning of the inside and outside of the greenhouse. When all the crop residues and weeds have been removed, the inside is washed and cleaned. This can be achieved by using GS-4 by Mardenkro. Use of GS-4 is simple. Dilute accord-

ingly, spray onto the glass and rinse off with water before it dries. All the dirt and algae simply wash away. Brushing is not necessary. Make sure that no droplets land on any plants still present because it can damage them. It is always better to use products such as GS-4 in an empty greenhouse. Some crops, such as bulbs and tubers, can be harmed by GS-4. Therefore you need to be extra cautious.

Despite the risks, GS-4 is often safer than other fluoride based glass cleaners. Conventional glass cleaners contain hydrogen fluoride gas, a product with harmful vapour activity. GS-4 is different to the conventional cleaning products because it contains no hydrogen fluoride. Therefore it is somewhat safer for people to work with GS-4.

Specialised contractor

Growers as well as specialised contractors use GS-4. Many contractors use Mardenkro's shading agent products in the summer and the cleaning substances in the autumn. They have the right machinery for the job and know in which situation GS-4 can and cannot be used.

Dutch spraying company Paul Sosef of Naaldwijk has been using GS-4 to clean greenhouses since it arrived on the market. Hein Wubben of Paul Sosef: “We advise the customer about which is the best product to use. If there's no

crop in the greenhouse or if there's a wall in between then we use GS-4. In the vegetable nurseries we use the fully automatic spray cart that rides along the heating pipes. A second spray cart that rides follows and rinses the glass clean. Wubben says that in recent years more and more greenhouses are being cleaned. “Hygiene protocols and viral pressure require growers to thoroughly clean the greenhouse.” He is pleased with GS-4. “New biological substances have been introduced in recent years but these can not yet match GS-4,” says Hein Wubben.



AntiCondens allows significantly more light into the greenhouse

KNOW-HOW Tomato grower Paul van Paassen was the first in the Netherlands to use the solution AntiCondens for glass. "It clearly leads to more light inside," he says.



Over the course of the year, for about half the time the glass is wet with condensation. That can reduce a lot of light. Researchers at Wageningen University & Research noticed during trials in 2010 that the manner of the

"The greenhouse now looks completely different. The condensation is still there but you don't see it."

condensation makes a big difference: if droplets form on the glass the light transmission is lower, if a water film forms transmission may even rise. On average they found that light transmission through ordinary float glass fell by 5% due to condensation. During the low light months in particular the glass is constantly fogged up. That costs production. An anti-droplet solution could ensure that virtually no light loss occurs, according to the report made by the researchers.



of the season with a cleaning agent the solution will largely disappear.

Over the past few years Mardenkro has further developed the existing solution for plastic greenhouses, AntiCondens, into a product suitable for glass.

First experience with AntiCondens for glass

Cluster tomato grower Paul van Paassen was the first to use it. In May 2016 he treated six panes of glass with AntiCondens as a trial. "That was convincing; you noticed immediately that there were no droplets on the treated glass," he says.

On the advice of his crop consultant he ordered AntiCondens at the end of the season and it was applied during the crop change in December 2016. AntiCondens has to be applied to clean and dry glass. Van Paassen: "That year was very humid in the greenhouse and the glass remained wet for a long time. Then you know you are losing light," he says. "There was exactly just one suitable day during that period. I had to put the heating on to dry the just applied solution."

AntiCondens lasts just one season. When the glass is cleaned at the end

More light in the greenhouse

The grower is very pleased with the results: "The greenhouse now looks completely different. The condensation is still there but you don't see it. As a result, it is definitely much lighter inside." He finds it difficult to estimate the effect it has on production and quality because one year can never be compared with another. "But I do think that I've gained from it," he says. Van Paassen intends to use AntiCondens again next season.

More light = more production

Mardenkro has measured the light transmission through treated and untreated glass. The differences were significant. On three consecutive days in May 2017 the light transmission through the treated glass was 6 to 7% better than through untreated glass. For tomatoes, an increase in light of 1% results in 0.7 to 1.0 % more yield (source: Wageningen UR).

SHADING



Effective protection against excess heat and/or light

Coatings that lower crop and greenhouse temperatures by reflecting heat-generating infrared light. The amount of grow-light that is transmitted depends on the choice of product.

Shading with ReduSol: a reliable solution for cooling the greenhouse

KNOW-HOW Nowadays, liquid greenhouse coatings are replacing chalk applications more than ever. These coatings are easy to apply, easy to remove and provide uniform shading. Coating with ReduSol is a good choice for people who have little or no experience with liquid coatings.

The best way to keep heat out of the greenhouse is by repelling external heat radiation. For this reason, growers have traditionally sprayed their greenhouses with chalk or repelling the heat by using an external shade-cloth. A more modern option is to apply wear resistant ReduSol on the outside of the greenhouse. ReduSol reduces heat radiation and is a more practical alternative for chalk or the installation of shade-cloths.

Easy to use

ReduSol has been on the market for over 25 years and many ornamental plant growers have had very positive experiences with this coating. The product is easy to use. It is already liquid, therefore easy to mix with water and causes no clogging of the spray equipment. Moreover, ReduSol is easier to remove from the greenhouse than chalk.

“The best way to keep heat out of the greenhouse is by repelling external heat radiation.”

Together with growers and through research, Mardenkro further developed the technology of removable liquid coatings.

Currently a series of coatings with advanced properties is available, like light diffusion or reflecting certain wavelengths of the light spectrum.

An average of 5 degrees less

Applying a liquid coating to the greenhouse roof changes the light circumstances in the greenhouse. This has an impact on the growth and development of the plants. If you have no experience with the ReduSystems products, the application of ReduSol on the greenhouse roof is a good way to experience the effect of a liquid coating. ReduSol provides full protection and is resistant to rain. A layer of ReduSol on the greenhouse roof reduces the average greenhouse temperature



by as much as of 5 degrees C. This benefits both the plants and the employees working in the greenhouse.

For glass and plastic greenhouses

ReduSol can be applied on glass and on all plastic materials. If ReduSol is applied to a plastic greenhouse, the lifetime of the film is extended because the coating blocks part of the harmful UV rays. Applied to a sidewall, ReduSol is a good way of reducing the radiation on that particular side. The coating is easy to apply and to remove manually or by machine if available (through a contractor). To remove ReduSol, Mardenkro has developed ReduClean, a mild cleaning product that is safe to use on glass or plastic film and will, after application, allow the rain to wash off the coating.

Custom ReduSol

Liquid coatings, such as ReduSol, can be applied in multiple layers. It is possible to increase the shading as needed when the light intensity increases. ReduSol can also be reapplied in places. The two layers mix together well, resulting in a lasting uniform layer on the greenhouse roof.

ReduSol can be mixed in multiple colours. Garden centres can, for example, mix a black colour through the liquid coating in order to apply a dark coating on the greenhouse in December, thus creating a Christmas atmosphere. Another application is the mixing of a green pigment for a better integration of the greenhouses into the landscape. This is done in Germany and other countries. The added colours of the coating have no effect on the removal of ReduSol.



Improved cultivation temperature

CONSULTANCY After several years of trial and error, horticultural company Young Sun, of Taiwan, has found a good solution for using ReduSol to protect its potted and bedding plants. The coating is applied to the sidewalls as well as the greenhouse roof.

“The plants clearly grow better because they experience less stress. In addition, it is also more pleasant to work in the greenhouse. I have already recommended ReduSol to a colleague.”

“Prior to using coatings we often had to resort to air-conditioning,” says Yang Teng-An, owner of Young Sun in Puli, central Taiwan. “If we didn’t, the temperature rose too high for our potted and bedding plants, such as anthuriums and begonias. Three years ago we started to use coatings. We tried several different types, such as ReduHeat and ReduFuse, and we eventually arrived at ReduSol.”

All sides coated

His greenhouse is 8000 m² and seven metres high. All sides are covered with the coating; this gives the best effect. It required some experimentation to discover the best way to apply it to achieve the best result in the wet tropical climate of Taiwan. “We now apply it twice per year to the sides and three to four times per year to the roof. We don’t wash

it off in between; during the season the rains make the coating thinner,” says Mr. Yang.

Lower greenhouse temperature

The greenhouse temperature has dropped by at least 2°C due to ReduSol. As a result, he doesn’t have to cool the house as much, which has led to substantial savings in electricity. Mr. Yang has not changed his ventilation strategy or the settings for the climate computer. The grower is very pleased with the effect of the coating. “The plants clearly grow better because they experience less stress. In addition, it is also more pleasant to work in the greenhouse. Now that we have figured out the best way to apply it we will continue this way. I have already recommended ReduSol to a colleague.”

Coating in layers is interesting for all growers

KNOW-HOW Growers ask many questions about light loss in relation to applying a coating. Through smart use of ReduSystems products it is possible 'to shade with the light'. Here a few tips!

In recent years experience was gained in applying ReduSol in several layers or a combination of two different coatings. By correctly applying the products in layers on top of each other it is possible to respond to the season. Mixing buckets of ReduSystems products together should be avoided as the products will lose their effectiveness.

Several layers of coating

ReduSol is the traditional coating that keeps heat out of the greenhouse. In the spring, complete coverage with ReduSol can cause too much light loss. Some chrysanthemum growers have been experimenting with applying several, thin layers of ReduSol. A thin layer in the spring reduces the intensity of the light and creates a mild climate in the greenhouse. This enhances flower colour

without reducing growth. As summer approaches and the sun becomes stronger, a second layer can be applied. By layering ReduSystems products on top of each other it is possible to more accurately respond to the needs of the crop. In cooperation with customers, Mardenkro has carried out trials that combine ReduHeat or ReduFuse with ReduSol, in which ReduSol is applied as the second layer.

“By layering ReduSystems products on top of each other it is possible to more accurately respond to the needs of the crop.”

Shade according to light conditions

ReduHeat allows a high degree of PAR-light to enter but reflects IR-radiation

(heat), ensuring sufficient light in the greenhouse for growth at the start of the season. As the sun becomes brighter we advise applying a thin layer of ReduSol on top of the ReduHeat. As a result you reduce the excessive radiation during the summer. During the course of the year the top layer of ReduSol wears away due to rain and UV-radiation, while the ReduHeat remains on the roof. This layer offers some protection in the event of any warm days in the fall.

At the end of the season both layers can be completely removed at the same time with ReduClean allowing the maximum amount of light to enter the greenhouse in the winter. A similar approach is also recommended when using ReduFuse (IR).



Read more online about controlling plant temperature with coatings:
Redusystems.com/block-ir



ReduSol is good for orchids

CONSULTANCY Since Apollo Farm in Don Duong, Vietnam, started using ReduSol, flower quality is better, screens are used less and working conditions have clearly improved.

Until five years ago Apollo Farm had not used any coatings. The company, which has 3 ha of glass greenhouses and 6 ha of poly greenhouses, was considering whether or not to invest in an external screen for the glasshouse. That idea was abandoned but it was still necessary to protect the plants, which it chose to do with a coating. ReduSol worked so well that the company also decided to use the coating on the poly greenhouses.

Apollo Farm is part of the Royal Base Corporation, of Taiwan. It is located 300 kilometres from Ho Chi Minh City and grows phalaenopsis pot plants, young plants and cut flower stems. "We specialise in producing cut flower stems. At the moment we produce 20,000 of them per week. We guarantee the consumer a certain quality and vase life," says farm manager Yaojen Liu. "We sell mainly to Japan and the USA but also to the rest of the world. A part remains in Vietnam itself - and this is a growing share."

High radiation

The region, around the provincial capital Da Lat, is 1000 metres above sea level. The climate is stable

throughout the year with a maximum temperature of about 32°C and a minimum of 10°C. "The radiation can rise to 1100 Watt/m²," says Liu. "And we notice that the maximum temperature has been rising in recent years."

Without protection from the sun, flower quality decreases. The orchid does need a certain sum of light, but if this becomes excessive it has a negative effect. By providing 60% shading the flower develops into a nice size.

Apply after rainy season

The farm manager is very pleased with ReduSol; the coating is also used on their main nursery in Taiwan. He sees no reason to change the current usage. "After the rainy season in October we apply a thick layer of about 20 to 25 buckets per ha. In February or March we apply an additional layer of 15 buckets/ha overtop. We have never removed the old coating previously but this year we are going to apply ReduClean to the greenhouse roof to give it a good cleaning," he says.



"ReduSol stays on well but there is some wear because occasionally we experience a tropical rain storm. We currently apply it manually but we are looking for another method in order to apply it more evenly."

Lower energy use

The coating also has had a positive effect on energy consumption. The areas of the greenhouse used for flower induction need to be cooled if the plants are going to produce good flower buds. With ReduSol on the roof the greenhouse is now not as warm so less energy is required for cooling. Overall, the climate in all areas of the greenhouse is much more uniform. As

"The orchid does need a certain sum of light, but if this becomes excessive it has a negative effect. By providing 60% shading the flower develops into a nice size."

well as the orchids the people working in the greenhouse also benefit. "It is a more pleasant working environment when the roof is coated," concludes Liu.

Daily light integral should be guide for optimal production of ornamentals

KNOW-HOW An increasing number of ornamental crop growers regularly measure the amount of light in the greenhouse. But just as important as the light level at any given time is the total light sum or daily light integral (DLI) received by the crop.



Light measurements were originally not developed for horticulture but for humans. The human eye is sensitive to roughly the same wavelengths as those in the Photosynthetically Active Radiation (PAR) range. But we see some colours better than others. This has clearly been taken into consideration with light measurements and is where the unit 'lux' originates. Some growers still express the strength of their artificial lights in lux. But this unit is not at all suitable to characterise the light used by plants. Light consists of particles called photons. The plant experiences every particle as being equal: Each particle contributes

equally to photosynthesis. Therefore, it is logical to refer to the quantity of light in number of particles. The unit used is a mole (or micromole μmol); One mole comprises an enormous number of particles, namely 6×10^{23} . Because there is a constant stream of light particles it is referred to as a flux which is expressed in $\mu\text{mol}/\text{m}^2/\text{s}$, so the number of particles per m^2 per second.

Measuring light in the greenhouse

Measuring light in the greenhouse is not easy. Although a PAR-meter, which measures the relevant part of the light, is available, its placement of a light meter is important. Also, the light varies with the time of day and with the weather. For each crop there is an optimal light intensity at which it functions best: highest photosynthesis and least stress. If there is insufficient light, production lags behind. So how do you know if the crop receives enough light if the intensity and the measurements always fluctuate? The daily light integral (DLI) can help answer this question. The DLI is the total amount of PAR light the crop receives on one day. Thus the amount of moles per m^2 per day: $\text{mol}/\text{m}^2/\text{d}$. Sensors are available that automatically register the DLI.

Optimal DLI

During the course of a year the DLI can vary substantially, from 2-5 $\text{mol}/\text{m}^2/\text{d}$ in low light periods in temperate regions to 25-30 $\text{mol}/\text{m}^2/\text{d}$ in the high season in regions with lots of light. Each crop has an optimal DLI-range. If the amount of light falls below this on any one day, not enough is produced. If it rises above this, light is wasted and damage may occur.

Also, the light level at any one moment makes a difference. If it rises too much, damage occurs even if the DLI remains within the limits. Purdue University in the USA has carried out a lot of research on optimal DLI. In general, the quality of the crop increases with rising DLI, until a maximum limit is reached. For many ornamental plants the researchers also noticed that the time to flowering was shorter, until a maximum limit was reached. In other trials they saw that bedding plants can often deal with a higher DLI, and therefore grows better and faster than usual. This is in line with research findings made by Wageningen University & Research on potted plants. These too could cope with higher light levels, provided that the humidity and the plant temperature can be kept within the limits.

DLI-categories

The Americans divide ornamental plants into four categories: shade plants (3-6 mol/m²/d), medium light crops (6-12 mol/m²/d), light loving crops (12-18 mol/m²/d) and high light loving crops (above 18 mol/m²/d). A few examples: Ferns, Maranta, Saintpaulia and Spathiphyllum flourish best at average DLI of 4 mol/m²/d.

Read more online about controlling plant temperature with coatings:

[Redusystems.com/block-ir](https://redusystems.com/block-ir)



“For real shade loving plants as well as the medium light crops ReduSol is a good coating that can shade out much of the natural light. If the crop can deal with more light, the preference shifts towards diffuse coatings.”

The American researchers include Phalaenopsis in this category although Dutch growers currently allow 5.5 mol at the beginning of the cultivation phase and increase that to 8 at the finishing stage.

A large range of well-known houseplants such as cyclamen and Kalanchoe are content with 6-8 mol/m²/d. Fuchsia and hortensia prefer it to be slightly higher. Carnation, potted rose and pelargonium are at the top of the medium light crops. Many garden and container plants have an optimal average of 12-16 mol/m²/d. Cut flowers such as alstroemeria, carnation, chrysanthemum and rose are in the category 14-20 mol/m²/d, where the last two can even cope with somewhat more.

Coatings

For real shade loving plants as well as the medium light crops ReduSol is a good coating that can shade out much of the natural light. If the crop can deal with more light, the preference shifts towards diffuse coatings. These remove bright sun spots which can cause damage. For the short term, the peaks in bright light can be shaded out with a shade screen.

In cases where a lot of light is desired, but where plant temperature should not rise too much, coatings that reflect infrared - ReduHeat and ReduFuse IR - are the best options.

Sweet Pepper grower ReduHeat fan

CONSULTANCY The sweet pepper greenhouse run by the Reedijk brothers, in Strijen and Westdorpe, the Netherlands, were some of the first to use ReduHeat. It prevents quality problems in the fruits.

Johan and Piet Reedijk run three nurseries at two locations in the Netherlands; in Strijen, Hoeksche Waard (2 x 3 ha) and Westdorpe in Terneuzen (8 ha). They grow sweet and chilli peppers in all shapes and colours: large and small,

sweet and hot. An unusual feature is that their greenhouse in Westdorpe, Zeeuws-Vlaanderen, does not have a natural gas connection. All heat comes from industry, which otherwise would burden the environment. “Just for insurance we



do maintain a back-up in the form of an oil boiler. But that has run for barely three hours," says Johan Reedijk.

A difference of opinion prevails among pepper growers as to whether shading with a coating is necessary. It is certainly true that the fruits can suffer from heat stress. "At such moments of stress there is a risk of problems with quality, such as blossom end rot and "burnt shoulders". We are convinced of the benefit of ReduHeat to shade out the heat," he says. "That has partly to do with the position of our greenhouse. The ridge is orientated in an east-west direction." That is positive for light transmission in the winter but it requires extra attention in the summer to prevent too much radiation entering the greenhouse. This can be achieved by using an energy screen or a heat reflecting coating. Reedijk prefers to use a coating because then he can better steer the greenhouse climate. "Quality is a high priority for us. With ReduHeat we can keep the technical aspects of production well under control. In a moderate climate the size of the fruits is better. If there is too much radiation the plants make more fruits and these are automatically smaller."

Helicopter

Both in Zeeuws-Vlaanderen and on one of the greenhouses in Hoeksche Waard the coating is applied with a helicopter. The reason for this is the speed of application. The vents have to be closed

during coating and so Reedijk wants this to happen as quickly as possible. "In addition coating with a helicopter produces a somewhat larger droplet. We've noticed that for us this produces a better effect. We have experimented a lot to find the right thickness of coating and now we've found the right dosing for all the greenhouses," he says.

ReduFuse IR

Last year they tried ReduFuse IR, the diffuse coating that also reflects heat. The grower was less positive about this. "Because diffuse light penetrates deeper into the crop we had more settings at the bottom. Peppers always have some after flowering at the bottom of the crop but this increased slightly. That is tricky: You see the fruits aren't hanging properly but to go through the crop just to pick these is difficult to do profitably. Therefore we simply went back to using ReduHeat. We are satisfied with this."

Adjust cultivation

Certainly in the beginning of spring you have to pay attention, he admits. "You benefit less from the first rays of sunlight that heat the greenhouse. Therefore early in the morning you have to provide some extra heating, about 1.5°C above the standard setting. On the other hand you can keep the vents closed longer and therefore keep more CO₂ inside. We haven't calculated exactly if these outweigh each other but we have a good feeling about it."

"Quality is a high priority for us. With ReduHeat we can keep the technical aspects of production well under control."





DIFFUSION

Maximum light diffusion with minimum grow-light loss

Coatings that allow maximum sunlight diffusion, while maintaining high levels of grow-light transmission. The amount of heat radiation (infrared) that is reflected depends on the choice of product.

Uniform light intensity best for crop

KNOW-HOW Plants show a delayed response to changes in light intensity. Actually they are always a few steps behind the reality and that reduces production. Diffuse light results in fewer changes and therefore to higher production.

If the light intensity in the greenhouse changes greatly, photosynthesis can be one third lower than when the light level stays steady. This is because the plant constantly has to get used to new circumstances.

Yet light changes continuously. Not only can a cloud move in front of the sun, light spots in the crop are constantly moving from place to place. In addition, the leaves themselves move so that they can be in or out of the light spots. The result is that there are always areas where the crop does not function optimally. Elias Kaiser of Wageningen University and Research has figured out which factors play a role and what the grower can do about them.

Stomata

It is well known that stomata need some time before they open to their maximum. This is particularly true at the start of the day. However, this is less important when the changes in light are rapid during the day. Then

the stomata simply maintain their original position for a few minutes.

More important is how the enzyme Rubisco functions. This plays a very important role in capturing CO₂, one of the first steps in photosynthesis. This enzyme has an active and an inactive form. The switch from inactive to active can take from five to 20 minutes. This explains the delay in the plant's response to changing light conditions.

ReduFuse

A grower can't do anything about the specific characteristics of the enzyme but can do something about the conditions; these have a lot of influence on the speed of the response.

To start, it's important to prevent the light spots from continuously changing. By using ReduFuse, the light level in the greenhouse is

much more uniform. The constant light level is an important explanation as to why a diffuse greenhouse roof leads to higher production. Namely the crop

“Prevention of changes in light by using ReduFuse and ReduFuse IR increases production.”



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doesn't constantly experience adjustment problems.

The CO₂-level in the greenhouse also plays an important role. At a low level (200 ppm) it takes at least 18 minutes before photosynthesis reaches the maximum. It takes just six minutes when the level is high (800 ppm). This is because the enzyme Rubisco is activated faster at a higher CO₂-level, in addition to the fact that the opening of the stomata plays less of a role when the level is high.

Humidity

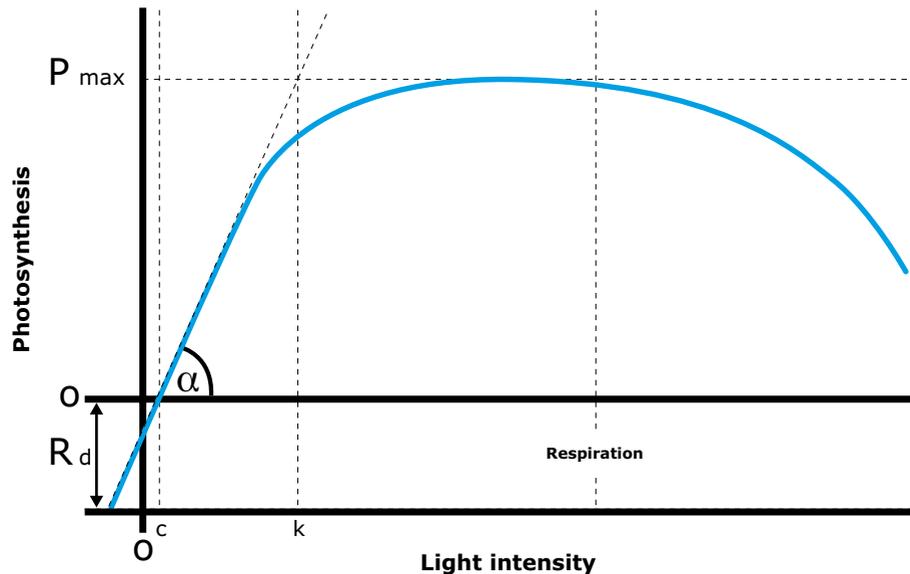
Finally, humidity is important. This has an effect on the opening of the stomata.

They close more at a lower humidity so less CO₂ can enter. This slows down photosynthesis but also Rubisco is less active at a lower level.

In summary: Prevention of changes in light by using ReduFuse and ReduFuse IR increases production. Furthermore a high CO₂-level and good humidity make a positive contribution to the crops ability to respond to changes in light that occur even when a coating is present - after all, a cloud can always pass by.

Coatings enable maximum efficiency of photosynthesis

KNOW-HOW The more light, the better the yield. But at a certain moment the leaves at the top of the crop have reached their maximum capacity. Therefore it is better to distribute the available light throughout the crop. That can be seen in the photo response curve.



For each crop, higher light intensity leads to more net photosynthesis within a certain section (see chart). The rise in this section is almost proportional to the increase in the light level. But at a giv-

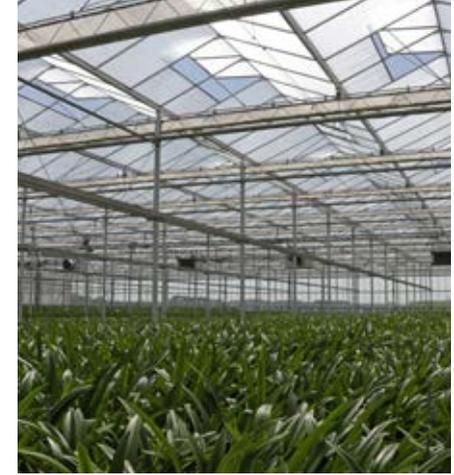
en moment it stops. Then the efficiency flattens out and can even fall if the light increases further. Then more light is harmful to the plant. The relationship between light intensity and photosyn-

thesis is different for each crop, as well as the point where the graph bends, but the shape of the graph is always the same. It starts at a point where net photosynthesis at low light intensity is negative. That occurs because the plant always respire, in other words it uses assimilates (sugars).

If there is insufficient light, it is at the expense of net assimilates because then consumption is greater than production. But when the light level rises enough sugars are very quickly produced again. This is the steep part of the graph where the efficiency increases. This is followed by the flat part and eventually the part where the line bends downwards and the efficiency decreases again. Decreasing efficiency, or even damage to the photosynthetic mechanism mostly occurs in countries where light intensity is very high. But also in temperate regions, such as the Netherlands, shade-loving plants can receive so much light that they become damaged.

Better light distribution

When the radiation is high the leaves at the top of the crop are at their maximum capacity. Extra light doesn't result in more photosynthesis and can even be harmful. Meanwhile many leaves at the bottom of the crop are a long way off their maximum production capacity. They would benefit greatly from more light. The chart makes it easy to understand the effect of coatings. A solar reflecting coating such as ReduSol ensures that the upper leaves don't enter the part of the response chart where more light becomes harmful, therefore



they continue to produce optimally. Also, the reflection of light ensures that the plant temperature doesn't become too high. ReduHeat focuses specifically on this last point: prevention of an excessively high plant temperature.

When using ReduFuse, light is better distributed throughout the greenhouse, both horizontally and vertically. Due to the vertical distribution, the upper leaves receive less light and therefore return to the steep part of the curve instead of the flat part. Leaves at the bottom of the crop receive more light as a result of the coating and their efficiency makes a move up the line on the graph. Both the leaves at the top and the bottom of the crop will function better. Together this leads to higher productivity when the light is diffuse compared with ordinary light. Thus the better distribution of light improves the total efficiency of photosynthesis. The aim is to have as many leaves as possible functioning in the steep part of the curve.



In depth: Climate control based on plant temperature is getting closer:

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ReduFuse IR and amaryllis

CONSULTANCY Amaryllis grow longer under a coating, resulting in larger bulbs and sturdier stems. Most growers (70-80%) now use coatings.

The amaryllis is not a shade plant, but is not really a sun lover either. Up until the cool period, it can use all the light it can get in the summer, as long as this does not lead to excessively high leaf temperatures. "The arrival of ReduFuse IR presented us with the perfect coating: sufficient diffuse light and a lower leaf temperature because of the reflection of infrared radiation", says Jan Overkleeft. He is an independent consultant who advises the majority of amaryllis growers in the Netherlands.

The advance of coatings in the cultivation of this crop is largely thanks to his recommendations.

The cultivation of amaryllis is concentrated in the regions Huissen, Noord-Limburg and the Westland, regions with very different

climatic conditions – it is much warmer and wetter in the east than on the coast. The yield per square meter is, however, such that new construction is not feasible and many amaryllis are grown in old, low greenhouses.

ReduFuse IR fits in perfectly

"A combination of ReduFuse and air humidification is adequate in contemporary high greenhouses, but not in lower greenhouses. In the past, ReduHeat was often used because

ReduSol is not suitable, the problem being that it reduces too much light, thus reducing growth. ReduFuse IR was just what we needed: it is the perfect coating. "Only growers with a very limited cooling capacity sometimes still have to use ReduSol on top of it", he continues.

Overkleeft tells growers that they hardly need to use screens if they use ReduFuse IR. Diffuse light penetrates deeper into the crop and the plant can use any amount of this diffuse light. "If the leaf temperature does not rise, the stomata remain open longer and assimilation goes on longer too. The first thing that struck me when ReduFuse IR came onto the market was that

the bulbs became bigger", the advisor says. "And bigger bulbs mean better stem quality. You can harvest sturdier stems, assuming of course that the other cultivation measures are properly observed."

You only need to close the screens for a while if the greenhouse temperature rises to 30-32°C in the summer. "At temperatures like that there is no growth anyway so it is all right to reduce the light. In that case, you shade the crop to keep it healthy", he adds.

"ReduFuse IR was just what we needed: it is the perfect coating."



Good information

Overkleeft recommends application of the coating around 1 April and to leave it until the harvest begins in October. Three quarters of Dutch amaryllis growers currently use a coating. "And people who start using it, stick with it", he observes. He is very positive about Mardenkro's approach. "They always give you plenty of background know-how. They explain how something works, give good information and, if something goes wrong, they solve it without problems. They also invited amaryllis growers to come and visit the factory at one point. I am very enthusiastic about the company."

Overkleeft follows the development of new innovative coatings with interest and is receptive to new possibilities.

Bulb cultivation

He feels that coated greenhouses could also contribute to better quality amaryllis bulbs. "Growers lift bulbs around 1 August and in the months prior to that you could boost growth under a diffuse coating. That would benefit the quality (the size of the bulb). But bulb cultivation is also under pressure and the costs have to be carefully considered. We do not have much experience yet, but growers who have jumped on board, are enthusiastic and do not revert to their old ways".

Diffused light for gerbera

KNOW-HOW Gerbera is a light sensitive crop that benefits from high sums of light. However, during the summer months, too much light can damage both growth and quality. Therefore gerbera crops always need to be protected. This can be achieved by using a coating, screen or a combination of both. In practice, we see that the combination of a fabric screen with a coating leads to the best results. Also, over the last few years we have seen a shift towards diffuse shading products.

Diffuse light

When light is diffuse a plant can often process a higher light intensity without any damage occurring. Diffuse light is scattered light. On clear days the light is direct, on cloudy days it is mostly diffuse. The amount of light diffusion is expressed as the haze factor. Clear glass has a haze factor of 0%, diffuse glass has a haze factor of 20-80% depending on the type of glass. Diffuse coatings produce a haze of 70-80% depending on the type of coating chosen and the concentration.

A few advantages of diffuse light are:

- Better horizontal light distribution
- Light penetrates more deeply into the crop
- Higher net photosynthesis
- Lower plant temperature which improves flower initiation
- Steadier climate which reduces the need to use screens
- Better flower quality
- More vigorous crop



Product	Buckets per ha	PAR		Infrared		Diffusion	
		Direct	Hemispheric	Direct	Hemispheric	Haze	F-scatter
ReduSol	11	20%	22%	19%	23%	*	*
ReduFuse	14	0%	6%	1%	8%	78	57
ReduFuse IR	18	6%	12%	11%	16%	72	37
ReduHeat	23	9%	10%	21%	20%	41	5

Figure 1: Net shading percentages

Coating

Gerbera benefits from lots of light so this needs to be taken into account when using a coating on the roof and therefore it is important to choose the right one. In practise several types of coatings are used: ReduHeat for heat reflection; ReduFuse IR for diffuse light and heat reflection; and ReduSol to reflect light and heat. The coating that best suits your situation is among other things dependent on the type of greenhouse, type of screen and crop variety. In practice, we see that ReduFuse IR is chosen more and more often for its diffuse and heat reflecting properties and also because it has high light transmittance.

The table above gives the shading percentages of the different coatings. These are net figures without glass. The hemispheric value gives the most accurate shading percentage.

When to apply which coating for a gerbera crop?

The greenhouse temperature remains lower when the roof is coated. ReduSol gives the best heat protection, but at the same time also shades out a lot of grow-light. When an extremely warm period is expected, or in more southern countries, ReduSol is sometimes applied as a second layer. Then a thin

layer is sprayed over ReduHeat or ReduFuse IR during the summer months. ReduHeat provides good protection against infrared light and at the same time allows high transmission of grow-light. ReduFuse IR has the additional ability to make the light diffuse. Then the crop temperature will generally be lower than when using ReduHeat, despite it reflecting less infrared. This lower crop temperature is mainly due to the higher diffusion capability of ReduFuse IR compared with ReduHeat. This is especially beneficial for producing more growth in generative crops.

However, the type of coating that best suits your situation is very dependent on the circumstances, such as type of greenhouse, type of screen(s) and crop variety. For tailor-made advice please contact Mardenkro or your crop advisor. Why use a coating if I have a screen?

In many cases one or more screens are already present in the greenhouse. If a black-out screen is the only one available, advantages can quickly be gained by applying a coating to the roof. In more modern greenhouses, in addition to the blackout cloth, a second screen is often present with a diffuse and sometimes open structure. Of course, this type of screen can reflect both light

and heat. A disadvantage however, is the limited amount of air exchange and, when the cloth has a closed structure, the fact that the screen cannot be fully closed because gaps will be required. Due to the lower air exchange the greenhouse temperature can become too high. This happens less when using a coating and it is possible to use the available ventilation capacity more efficiently. The screen can then be used to flatten out the light and temperature peaks over the course of a day.

When to apply

ReduHeat and ReduFuse IR can often be applied fairly early in the spring. In April the radiation can rise a lot and a young crop can quickly find itself in a stressful situation. Experience has taught that, for a sufficiently generative gerbera crop, applying the coating in time only leads to advantages. The timing of the application is mostly dependent on the weather forecast and the crop conditions. The time to apply a coating should be a bit earlier with a generatively growing crop than with a very vigorous or vegetative crop.

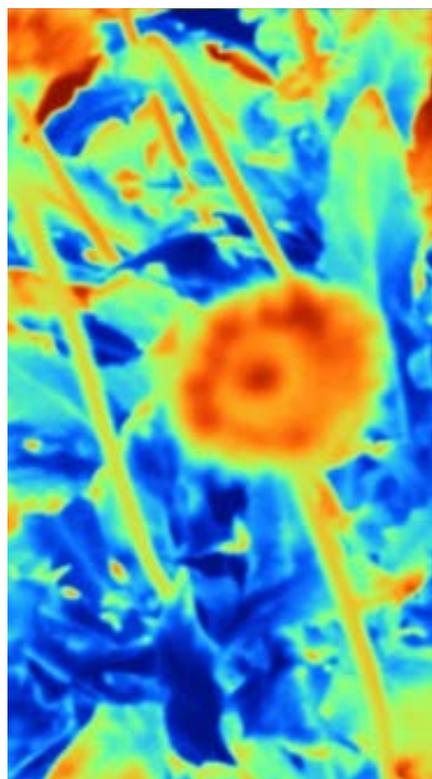
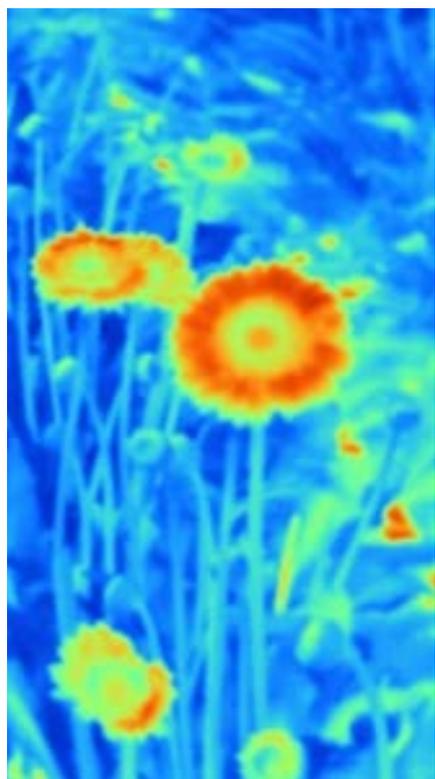


Figure 2: Infrared photos of a gerbera crop under diffuse light (left) and direct light (right). The crop temperature on the right is clearly higher (more orange and yellow).



Better quality with ReduFuse coatings

KNOW-HOW The ReduFuse and ReduFuse IR coatings not only ensure that vegetable crops yield more, they also lead to a considerable improvement in quality: Less blossom end rot in cherry tomatoes and sweet peppers, no anthocyanin formation in yellow peppers and more productive high wire cucumbers.

The yield of vegetable crops grown under a diffuse greenhouse roof increases by 5 to 10 per cent, according to research by Wageningen UR. However, replacing standard glass with diffuse glass in existing greenhouses is

hardly an option. For these greenhouses Mardenkro supplies two coatings that turn the sunlight entering the greenhouse into diffused light, namely ReduFuse and ReduFuse IR.

Generative or vegetative

Applying a diffuse coating to the greenhouse roof affects the development of the crop. Diffused light penetrates deeper into the crop and therefore reaches the lower leaves. As a result, photosynthesis by the plant increases and the crop is more productive. Thanks to the better light distribution throughout the crop it experiences less stress and growth is stronger. For crops that are naturally strong growers, such as the popular tomato variety Merlice, it is not recommended to use a coating to create diffused light in the greenhouse. The grower would not be able to steer the crop sufficiently generative. However, there are situations that a diffuse coating for fast-growing crops makes sense, such as for crops grown under artificial light and production in southern countries.



“Diffused light penetrates deeper into the crop and therefore reaches the lower leaves. As a result, photosynthesis by the plant increases and the crop is more productive.”

Better quality

In addition to higher production, applying ReduFuse or ReduFuse IR to the roof leads to important quality benefits in various vegetable crops. A few examples are:

Sweet pepper

- Fewer deformed fruits
- Less sunburn
- Yellow peppers have fewer problems with brown spots on the fruit due to anthocyanin formation
- Sweet pointed peppers have less blossom end rot

Tomato

- Cherry tomatoes have less blossom end rot
- Better pollination by bumble bees

Cucumber

- High wire crops suffer less stress at the top of the plants. This results in better growth and less fruit abortion

Strawberries

- Larger fruits
- Better pollination

Product	Buckets per ha	PAR		Infrared		Diffusion	
		Direct	Hemispheric	Direct	Hemispheric	Haze	F-scatter
ReduSol	11	20%	22%	19%	23%	*	*
ReduFuse	14	0%	6%	1%	8%	78	57
ReduFuse IR	18	6%	12%	11%	16%	72	37
ReduHeat	23	9%	10%	21%	20%	41	5

* Haze is the measure of light diffusion

The choice between ReduFuse or ReduFuse IR in vegetable cultivation depends in the first place on the location of the greenhouse. In the Netherlands it is usually not necessary to use ReduFuse IR, but vegetable growers with older, low greenhouses do have positive experiences with this coating as it keeps the temperature in the greenhouse during the summer months at an acceptable level.

In southern Europe is very important to reflect heat so ReduFuse IR takes preference over ReduFuse.

ReduFuse or ReduFuse IR

The difference between ReduFuse and ReduFuse IR lies mainly in the heat reflecting properties. Unlike ReduFuse, ReduFuse IR reflects part of the heat rays, the infrared (IR) light. In addition, this coating reflects a small percentage of the PAR light.



Dosing

The number of buckets of ReduFuse or ReduFuse IR that should be applied is determined by:

- Possibilities for ventilating the greenhouse
- North-South orientation
- Presence of screens
- Height of the greenhouse

The required number of buckets of ReduFuse IR per ha is generally higher than the number of buckets of ReduFuse.

Every situation and geographic location is different which makes that the ideal diffuse coating can vary greatly. To facilitate your choice, we have brought together our experience and knowledge in an online advice tool; ReduWizard.

Try ReduWizard at [Reduwizard.com](https://www.reduwizard.com)

Low-growing ornamental crops benefit from diffused light

KNOW-HOW Low-growing ornamental crops such as potted plants and gerbera perform better under diffused light. The micro-climate around the plants is more even, and the light penetrates better into the crop.

In the early years of using diffuse glass and coatings, growers thought that mainly tall-growing crops would benefit from better light penetration. This assumption was proven wrong. It makes no difference if the leaf area index (LAI: m² of leaf per m² surface area) is structured in layers of several metres or just a few dozen centimetres.

Thanks to a diffuse coating, the light penetrates deeper into the plants because it is scattered. It seems as if the light comes from all sides, rather than just from one side. This means that more leaves receive enough light for active growth.

Absorption of light

If light falls on a leaf, three things happen.

- Some light is reflected; this accounts for about 5-15%. This light is lost, or caught by another leaf.
- Most is absorbed by the leaf; this accounts for an average of three quarters of the light.
- A small amount of light shines through the leaf; this accounts for about 5-10%. This light can be used by lower leaves.

Absorption does not mean that all this light is actually used for photosynthesis. Many potted plants are originally shade plants and quickly receive too much.

These plants have several ways to mitigate the excess of light: fluorescence, non-photosynthetic quenching, photo inhibition.

“Better light distribution enables increasing the general light level, which also enhances production.”

Such processes are all designed to prevent harmful effects, either by diverting the light energy away, or by temporary suspension of the photo synthesis system. The defence against too much light energy is successful only to some extent. At high levels, damage is incurred due to formation of free radicals which break down everything around them, including cell membranes, enzymes and DNA. This shows up as discoloration or parts of the leaf dying. This is referred to as leaf burn.

Better light distribution

In order to prevent leaf burn, the grower may limit the quantity of light. Alternatively, the grower can also use a diffuse coating and improve the distribution of the light, preventing concentrated spots of excess solar energy. Such concentrated spots, the solar spots, is where the stress levels become excessive, raising the plant temperature.

Wageningen University & Research experiments proved that many crops are able to deal with a higher light level, provided that the light is evenly distributed. It also requires

humidity levels to be maintained and temperatures that don't go to high. Even distribution of light can be achieved by using ReduFuse.

ReduFuse IR also limits the greenhouse and plant temperatures from getting too high.

Micro-climate

Diffused light provides a better micro-climate around and between the plants. Without a diffuse coating, the crop is confronted with alternating bright solar spots and harsh shadows, both of which keep moving. These continuous changes raises the stress level to the plant and also unevenly distributes these stress levels. As a result, the crop now consists of plants with good performance and plants with high stress levels. As the crop itself helps create it's own micro-climate (because of evaporation and emitting heat) it now causes an unbalanced micro-climate. In the greenhouse, horizontal and vertical differences occur in both temperature and humidity. This can lead to uneven growth and even to higher susceptibility to disease in certain spots.

From all experiments conducted by Wageningen University & Research in the past few years, the impression is that diffused light creates a more even climate in virtually all crops, improving crop performance. This alone leads to higher production and higher quality. Additionally, better light distribution enables increasing the general light level, which also enhances production.



In depth: Climate control based on plant temperature is getting closer:
[Redusystems.com/control](https://www.redusystems.com/control)

Bumblebees benefit from coating on the roof

KNOW-HOW Bumblebees don't like extreme temperatures. Therefore, if the roof is coated they often function better and that improves their effectiveness.

Bumblebees are known as insects that function well under greenhouse conditions. Eventhough these conditions are actually not optimal for insects. Under a greenhouse roof bumblebees don't have any trouble with their orientation. They are however sensitive to high greenhouse temperatures. Then they stay in their hive and keep themselves cool.

Bumblebee specialist Remco Huvermann, of Koppert, explains the consequences that can have: "As the temperature becomes high they are no longer active from around 10 or 11am. That means they are only flying around for a quarter of the normal time. In addition, the hive can become too hot, which is not good for their health."

Active longer under coating

Coatings that reflect light and heat (infrared), such as ReduSol and ReduHeat, therefore have a positive effect on the functioning of the bumblebees. "They stay active longer which means pollination is less likely to be put into jeopardy. They also stay healthier if their home base stays cooler. Pollination takes place much better and you have fewer setbacks in fruit setting," he says.

The latter is a result of the interaction between plant and pollinator. An extreme greenhouse climate or high radiation can lead to pollen of poorer quality. "The bumblebees smell this and skip these flowers. A heat wave has a double negative effect: Initially the bumblebees don't fly enough because it is too hot and they have to actively cool their hive. In addition, one to two weeks later the bumblebees may ignore the unattractive flowers that were formed during the heat wave. A light or heat reflecting coating therefore has a twofold effect," he says.

A missed tomato costs money

A diffuse coating, such as ReduFuse or ReduFuse IR, also has that dual effect. The top of the plant heats up less so that the quality of the pollen remains good. Also the bumblebees feel better in the milder climate and fly around and continue to pollinate the flowers. "In addition, because diffuse light penetrates deeper into the crop, the bumblebees can orient themselves better. They find more flowers and don't waste energy because they are better able to find their hive again. It's good to remember that every setback costs money. When



the pollination is poor, growers find that they can miss a tomato. Also, missed fruit cause an imbalance in the plant so you have to adjust for this," says Huvermann.

The combination of artificial lighting during low natural light provides an additional challenge for bumblebees. Bumblebees are not able to see red light,

the colour that dominates in artificial lights. They have difficulty in orientating themselves and would waste too much time finding their hive again. This is time not spent on pollination. For that reason Koppert developed special hives that the bumblebees can easily find by means of colour signals and reflections.

Diffused light virtually always better

KNOW-HOW All fruit-bearing vegetable crops benefit from diffused light. The total photosynthesis increases through better light penetration and reduced heat stress.

In recent years, extensive trials were performed to assess the benefits of diffused (scattered) light. Initially, it concerned trials to demonstrate for each crop if added value was achieved. Subsequently, the researchers assessed why diffused light leads to higher production and better quality. Lately, the research goals are more about fine-tuning.

“Under a diffused greenhouse roof there are no light spots or hard shadow lines.”

Based on the trials, researchers concluded that virtually any crop benefits from scattered light. In general, higher scattering is better (higher haze or F-scatter value). For each crop, it is necessary to consider if the benefits outweigh the loss of light in a certain period. Modern diffuse glass has virtually no loss of light. A diffuse coating lets any light from a straight angle in with virtually no loss. Any slanted light is reduced by only a few percent. In spring and summer, the benefits certainly outweigh such small losses.

Better horizontal light distribution of great importance

Research done by Li Tao (Wageningen UR) significantly enhanced our insight into the benefits of diffused light. The light is distributed better, both in horizontal and vertical terms. Remarkably, the improved horizontal light distribution is even more important than the improved vertical distribution, while in the early years,

deeper light penetration was one of the main arguments.

Under a diffused greenhouse roof there are no light spots or hard shadow lines as the light is evenly distributed. Better horizontal distribution prevents that individual plants or leaves have to continually adjust to different light conditions. These adjustments are hard on the plants, as shown by the research results of Elias Kaiser (Wageningen UR). It can take up to fifteen minutes for the photosynthesis system to adapt to the new light conditions, and it may have changed again during that time. Photosynthesis, in particular storing CO₂ by the Rubisco enzyme, therefore continuously lags behind the conditions. This costs production, and the losses can be significant. It is therefore important to dampen these changes in light intensity: ReduFuse or ReduFuse IR are excellent instruments to achieve this.

Preventing heat stress

The vertical distribution light is also important. Under a diffuse coating, the top leaves receive a little less light and the leaves in the middle receive a little more. Both aspects work in our favour: heat-stress to the head of the plant is avoided, and the middle leaves participate more active in the photosynthesis.

Heat stress has a number of phases. First, the plant will start evaporating far more at rising leaf temperatures. This means that the grower has to ventilate to control humidity. During continued over-heating, free radicals





are formed. These are molecules that react spontaneously with everything around them and thus damaging everything in the cell, including the photosynthesis system. A special point of attention is photo inhibition. If the plant receives too much light, it suspends the photosynthesis system for protection. This does not cause damage

- but there is a limit. After some time, the high light level, in combination with the increasing leaf temperature, causes the formation of free radicals. This is why ReduFuse IR is highly recommended in hot climates. The coating provides better light distribution while reflecting the harmful infrared radiation.

Through better light distribution, both horizontal and vertical, under the diffuse coating, the crop changes. More leaves will become active, increasing their photosynthesis capacity. The quantity of leaves in the greenhouse also increases.

Combined, all these aspects result in better growth and production. The production increase is different for each crop but amounts to 5 to 10 %.

“In greenhouses with diffuse coating, crop consultants see better setting, heavier fruit and fewer quality issues.”

Cucumber

Ten years ago, cucumber was the very first crop for diffuse glass trials at Wageningen UR Greenhouse Horticulture. Under an older version of diffuse glass (with 4% light loss), production increased by 4.3% and the number of fruits increased by 7.8%. The researchers estimated that without any light losses, the production would have increased by 7.8% in kilos and by 11% in the number of cucumbers. This was a crop grown from April through July.

At high radiation, the temperature of the crop was 0.2 to 0.8% lower in the top, and 0.4% higher in the bottom of the crop under the diffuse roofing, compared to regular greenhouse glass. Five years later, a trial with an early cucumber crop resulted in production at 6% higher, with both more cucumbers and heavier fruits.

At Mardenkro's request, Botany Horst researched an early stage ReduFuse. A summer crop under the diffuse coating resulted in a 4.3% production increase and 7.1% increase in class I

fruits. Remarkably, the crop in the greenhouse with the coating was more vibrant after a period of heat. ReduFuse was further improved since this study.

Tomato

Most research has taken place with tomato plants. Wageningen UR Greenhouse Horticulture found an increase in production by 8-11% for year-round crops under diffuse glass. The production under ReduFuse was higher by 5% (started in May, removed in early September). The higher production was mostly due to a slightly higher fruit weight and to a lesser extent to the increased formation of clusters.

The crop under the diffuse roof, including ReduFuse, was less sensitive to Botrytis. The milder greenhouse conditions causes increased resistance. The dry matter content of the stems was slightly higher, therefore reducing potential loss due to Botrytis.

In greenhouses with diffuse coating, crop consultants see better setting, heavier fruit and fewer quality issues. ReduFuse sees the best results with a somewhat generative crop.

Pepper

Because of trials in years with a poor

summer, the results of Hoogstraten Trial Centre were less convincing. Still, the use of diffuse coatings is significantly increasing among paprika growers. Practical experience seem to be more leading than research results. Growers report better fruit quality in summer, higher production, lower plant temperature and better control capabilities, thanks to a more stable greenhouse climate.

From Mardenkro's own measurements, it is clear that fruit temperature is over 5°C lower under ReduFuse compared with an uncoated greenhouse roof. This significantly reduces the risk of burned fruits, which, for sensitive varieties, is a major benefit.

Because evaporation remains at a more stable level in an even greenhouse climate, calcium issues such as blossom end rot occur less.

In Dutch conditions, ReduFuse is mainly applied in green peppers and sweetpoint peppers. In Central and Southern Europe, growers mainly apply ReduFuse IR for these types of peppers, and ReduFuse is applied to all sweet peppers.

SPECIALTIES



Crop specific coatings

In the Mardenkro laboratory, new products are continuously developed in association with leading international research institutes, universities and growers.

The specialities group consist of coatings designed for specific crops or climatic conditions. It also includes innovations that are to be tested further for efficacy in various crops.

Potential to steer crop with blue light

KNOW-HOW Crop development can be steered by using blue light. Insights into the possibilities are continuously growing as a result of joint research.

Even though plants don't have eyes, they can "see" whether it is day or night, determine the length of a day and see the colour of the light. They do this by using light sensitive pigments. But besides being their eyes these pigments are also control centres: they send instructions which impact crop development. These are very complicated processes with many intermediate steps not all of which are known. But in recent years our knowledge about them has grown enormously.

Blue light

There are different types of light sensitive pigments: cryptochromes, phototropins, phytochromes, ZTL and UVR8. Each responds to a certain part of the light spectrum. The first two are important for blue light.

As is common in plants, these pigments do not have just one function, but they steer several processes. Cryptochromes and phototropins have an effect on the biological clock, growth towards light, opening of the stomata, elongation of the plant, bud development and the shape of the leaves. This means that these processes can be steered with extra blue light (such as LEDs) or by reflecting a part of the blue light with

the coating ReduFlex Blue.

However, this is not a simple operation because it not only involves blue light but also, for example, the relationship with red light. Other pigments, the phytochromes, respond directly to this light colour.

Club of 100

Financed and supervised by the Club of 100, of which Mardenkro is also a member, Wageningen UR Greenhouse Horticulture has been researching the possibilities of steering with light colour. At the moment the most potential seems to lie in steering plant length. While you want potted plants to remain compact, cut flowers such as roses should preferably be longer. This can be achieved by altering the relationship between blue and red in the light.

Sunlight naturally contains 31% blue light, so a relatively high proportion. Therefore, as research shows, adding just a little blue light has little impact on tomato and potted plants. The ratio of blue:red has to change significantly. In addition to the blue:red ratio, altering the ratio of red:far red at the end of the day can have a greater effect, according to research on fuchsias. Relatively more blue during the day, and relatively

more red at dusk (compared with far red) results in more compact fuchsias. No effects were noticed in hibiscus. Research will continue in the autumn and this will look at the opportunities offered by coatings.

ReduFlex Blue

Less blue light can lead to more elongation which is desirable for cut roses.

The proportion of blue in natural light can be reduced by using the coating ReduFlex Blue. Research carried out by Delphy (previously DLV) and the experiences of growers show that roses grown under the coating can have longer stems; the amount depends on the variety.



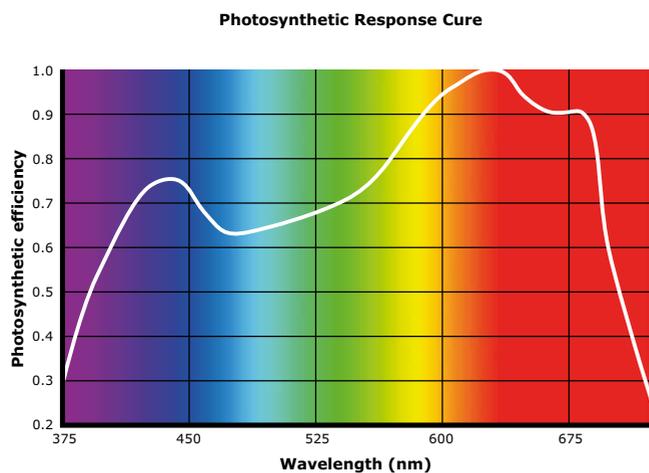
Colour of the light is important

KNOW-HOW The colour of light affects the efficiency of photosynthesis but also growth and development. It is becoming more and more possible to work with these facts.

Many led-lights contain red, blue and far-red led's. This easily gives the impression that these are the most ideal colours for plant growth and development. But this requires a clear explanation. When it comes to light colour it is necessary to distinguish between two things: the influence of colour on photosynthesis and its influence on development.

With respect to led's, red produces the most light output per kW electricity. This is the reason that this colour is dominant in the fixtures. Because a plant cannot grow with purely red light, blue

and sometimes far red light are also added. But plants do utilise the other light colours quite well. This is shown in the McCree curve: there are peaks in red and blue but photosynthesis is certainly not zero in the other colours. Currently it is already possible for leafy crops and some types of green potted plants to be grown under led-light. That is still "out of reach" for flowering ornamental plants. Still, all crops grow better under sunlight which, the full colour spectrum, Trials have shown this time and time again.



Sunlight consists of UV, PAR (photosynthetically active radiation) and infrared. As the name implies, only PAR is important for growth. Half of the solar energy is in the infrared part of the spectrum and it is this which contributes an important part to heating the greenhouse. Because it is not

needed for photosynthesis, shading out infrared (heat radiation) is a good idea. Suitable coatings for this are ReduHeat and ReduFuse IR.

Light colour determines development

The colour of the light also determines the development of the crop: the amount of elongation, how much it branches, when it flowers etc. The intensity of light is very important for photosynthesis but for steering the development of the crop much minor light differences can already be enough. For example a very small amount of red light during a long night is enough to keep chrysanthemums vegetative.

It is the relationship between the colours that gives light its steering effect. For example, the ratio between red and far red: More red results in more compact plants. The ratio between red and blue is also important. Less blue (and therefore more red) leads to roses with longer stems.

This example shows that it's not quite that simple: on the one hand more red results in more compactness and in the other more elongation. Keep in mind that it is always about the colour to colour ratio. In practice it is difficult to steer with light colours. After all, there is always an ample amount of sunlight available. In order to change the ratios during the day, you would need to add a lot of the desired light colour. Son-T lamps contain so much red light that at low levels of natural light there is a definite red-light effect. Extended lighting at dusk (to change the ratio red:far red) can lead to more compact plants, according to research by Wageningen

University Research on fuchsias. Rose growers have had good experiences with the coating ReduFlex Blue which partly blocks blue light. They can harvest longer roses under this coating. In this case it is the ratio of red:blue light that causes the effect. There are many interesting developments in the field of light colours, but practical application or applying the results to other crops is still difficult.



Van den Ende Rozen has used ReduFlex Blue for three seasons: [Redusystems.com/3seasons](https://redusystems.com/3seasons)

Wageningen University & Research has achieved spectacular results with tomatoes under extra far-red light. The plants sent more assimilates to the fruits. It is still unclear whether such results can be applied to ornamental plants, like gerbera or rose.

ReduHeat or ReduFlex Blue?

KNOW-HOW The arrival of photoselective coatings on the market has allowed more crop specific light to be offered to the plant. ReduHeat is the first photoselective coating that has been specially developed for horticulture. Many growers want to keep heat out of the greenhouse but aren't prepared to sacrifice grow-light. This led to the development of ReduHeat, a coating that allows maximum transmission of light yet it reduces heat by reflecting infrared light.

Plant research increasingly focuses on the role of light colour in the plant. In recent years a lot has been discovered about the function of different receptors in the plant and their reaction to different light colours. Mardenkro used this knowledge to develop photoselective coatings, which we market under the name ReduFlex. One of these developments is ReduFlex Blue.

Properties of the coatings

A property of ReduHeat is its ability to reflect infra red light while transmitting grow-light. Infrared light is an important factor for warming the greenhouse and the crop. When using ReduHeat in warm periods of the year, a portion of the infrared light is reflected, so the

temperature clearly rises less rapidly. The table below shows the different shading percentages per product (excluding glass).

One of the properties of ReduFlex Blue is that relatively more blue light is reflected. The blue part of the light spectrum also affects the elongation of plants. By altering the relationship between blue and red light, more elongation of the crop occurs. The ratio of red and far red light also affects the elongation of the crop. For enhance elongation ReduFlex Blue has a more favourable ratio of red:far red than ReduHeat. In addition, ReduFlex Blue also has infrared reflecting properties.

Product	Buckets per ha	PAR		Infrared		Diffusion	
		Direct	Hemispheric	Direct	Hemispheric	Haze	F-scatter
ReduHeat	23	9%	10%	21%	20%	41	5
ReduHeat	27	11%	13%	25%	24%	46	7
ReduFlex Blue	18	12%	13%	13%	16%	44	6
ReduFlex Blue	22	15%	16%	18%	21%	53	13

Figure 1: Net shading percentages

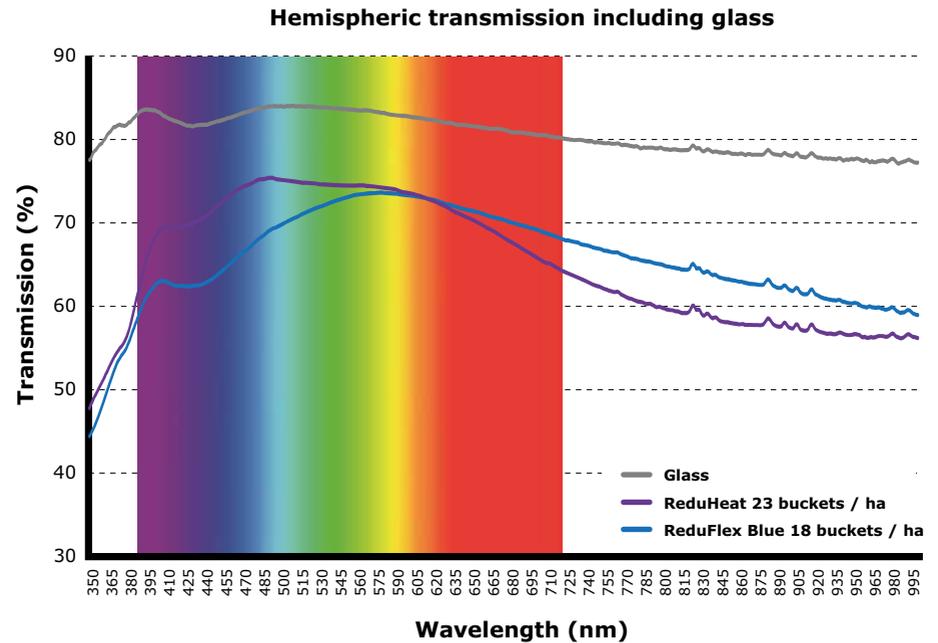
Which coating for which crop?

A crop that benefits from ReduFlex Blue is the rose (cut flower). During the summer months it can be difficult to achieve flower stems of the desired length. By using ReduFlex Blue it is possible to gain more length. An additional positive effect is that the flower stems are heavier and new shoots develop more easily. As well as roses, positive effects have also been seen in freesias harvested in the summer. Here we see mostly heavier stems and better development of side shoots. ReduFlex Blue has also been used with carnations. This crop also responds by producing longer stems and more buds. Positive results from this coating have also been seen in orchid crops. This is mainly reflected in a more intense flower colour.

The PAR light transmission by ReduHeat is higher than that of ReduFlex Blue because the entire spectrum is transmitted. ReduHeat is often used with crops that can tolerate a lot of light, but where too much heat can lead to quality problems. Some examples are crops such as chrysanthemum and gerbera. The spectrum of both coatings is shown in the chart below.

Finally

The choice of coating is dependent on the crop, production schedule and the purpose for which it is applied. In addition, the technical equipment in the greenhouse, such as screen fabric type(s), is also important when deciding on the type and concentration of the coating to use.



Longer roses under ReduFlex Blue

CONSULTANCY When it becomes very warm roses quickly tend to remain too short. Nice2Get! now has three seasons of experience with ReduFlex Blue. "We clearly see more stem elongation," says owner Robert Koot.

Visitors to this year's Keukenhof, Holland's famous outdoor flower show, chose Harlequin by Nice2Get! as the most beautiful rose of the year. Some 30,000 people voted for the rose via computer. It was a clear indication that the bi-coloured rose (red and white) is very popular.

However, it is not an easy variety to grow, says Robert Koot. "It can't withstand a lot of heat or light and stem length lags behind in the summer.

If you don't use a coating you stand to lose a lot. Since we started using ReduFlex Blue we see considerably longer stems."

Determined by blue/red ratio

The stem length is an important quality characteristic of roses and other cut flowers. It is known that the ratio between blue and red light partly determines the elongation in the crop. Knowing this Mardenkro developed ReduFlex Blue. The coating allows less blue light to penetrate and hence results in more

stretching. In addition, it reflects an important part of the infrared, keeping the greenhouse temperature lower. Nice2Get! grows five varieties of roses in 7.5 hectares of glasshouses in Nieuwveen, the Netherlands. The company

pays a lot of attention to quality and grows according to the environmental certificates MPS-A and MPS Socially Qualified, indicating that they meet high requirements in terms of environment, safety and health.

More stretching

"In the past we didn't use a coating but instead used a screen," explains Koot. "This leads to a crop with chlorosis and shorter stems. This improved a lot when we started using ReduHeat." Based on advice from a crop consultant two years ago we decided to try ReduFlex Blue. We are now in the third season and we notice that this coating allows in more light and indeed leads to more stem elongation."

Due to the higher PAR-light level, compared with using the screen, the crop

"We are now in the third season and we notice that this coating allows in more light and indeed leads to more stem elongation."



Also Van der Ende Rozen has used ReduFlex Blue for three seasons: Redusystems.com/3seasons

can optimally produce assimilates. Koot notices that the heat reflection property reduces greenhouse temperature and produces a more vigorous crop, which clearly produces longer stems. He doesn't know exactly how much difference it makes to the length because all the greenhouses are now coated with ReduFlex Blue.

Promises fulfilled

Compared with ReduHeat the number of hours that the screen has to be used is the same. Compared with the old situation - without a coating - the number

of hours when screens are needed has dropped substantially. "I like this coating; it does what it promises. Also, it stays on well; it was just as thick at the end of the season as at the beginning and it was easy to clean afterwards," says Koot. Due to the cool summer he decided to remove the coating in week 33. Right after the roses had to deal with an unexpected heat wave so the screens had to be used a lot. "You learn the hard way. The weather is much less predictable which makes it more difficult to choose the right moment to remove the coating," he states.

Light colour and intensity affect biological balance

KNOW-HOW Both pests and their natural enemies respond to the colour and intensity of light. This means that coatings can affect the biological balance in greenhouses.

A grower who changes the light in the greenhouse by installing more artificial lights or applying a coating to the greenhouse roof, for example, unknowingly influences the insect population. Both harmful and beneficial insects are sensitive to light colour and intensity. We are learning more and more about this field, which is a good thing now that new types of lamps, such as LEDs, and new coatings are advancing. After all, they may have new effects.

Light colour and intensity affect how well

pests find plants, how they find their bearings in the greenhouse and how active they are. And the same applies to their natural enemies. The day length affects their life cycle, particularly when they enter diapause, or become dormant. Because of the many different effects, it is often difficult to predict how a change in lighting will affect the balance between what is beneficial and what is harmful. Despite the above, a number of principles are now clear.

Ultraviolet light

Most pests are attracted to ultraviolet (UV) light and are clearly more active in an environment with a lot of UV light. Unlike people, they are able to see this colour distinctly. Thrips, whitefly, leaf miner fly, aphids and red spider mite can find their way and spread better through the crop under UV light; in other words, they can find plants more easily and eat more. At lower UV intensities, they are less successful at doing so. This is therefore a starting point for the control of these pests. Scientific research in various countries has now shown that it is worthwhile keeping UV light out of the greenhouse.

If glass or plastic film greenhouses are coated with UV-resistant materials, fewer pests fly in and those that do are far less active once they are in the greenhouse. An interesting point is that their natural enemies are less affected by the reduced UV levels. This is because they primarily find their prey by smell.

In a glass greenhouse the UV level is already low, but this does not apply to a plastic film greenhouse. In the latter it is certainly worthwhile to prevent the incidence of UV light (provided it is not necessary for the colouring of tree nursery crops, for example). ReduSol reflects UV radiation to a certain extent. Work is currently being carried out on special UV-reflecting coatings.

A disadvantage of UV protection is that pollinators, such as honeybees and bumblebees, can't find their way as well in the absence of UV light. In the case of crops that have to be pollinated, the decision of whether to use UV protection must therefore not be taken lightly. Bees

in particular need several days to get used to the situation if ReduSol is used. It helps if beehives are placed close to the greenhouse gables.

Other light colours

Other wavelengths of light, that is, different colours, also affect insects. There is a reason why sticky traps are yellow or blue: these are the colours by which insects are attracted. Red light can also be effective in reducing damage, but this works via a different mechanism. When exposed to a relatively high level of red light, a crop produces more antibodies, so that it is more resistant to pests. The ratio of red to far-red light is the determining factor in this mechanism and not the absolute level of red light. High-pressure sodium lamps (SON-T) produce relatively high levels of red light and therefore have a positive effect.

More light: more resistant crops

A high light intensity and a longer light period also yield a crop that is more resistant to insects. If a grower can take measures to increase the incident light, he or she will therefore have a healthier crop. Coatings such as ReduHeat, ReduFuse and ReduFuse IR are significant aids to this end.

Growers report that diffuse and/or heat-reflecting coatings also have a positive effect on biological pest control because breeding bags of these natural enemies heat up less when there is less light or the light is diffuse, as a result of which the beneficial insects remain more vigorous.



First practical trials: ReduFlex Green keeps bedding plants compact

In a practical trial with bedding plants, the plants grown under ReduFlex Green were found to be more compact in comparison with those grown under uncoated glass. Larger scale trials with more crops will take place in 2018.



Various studies by Wageningen University & Research have shown that green light affects plant shape and light interception. Tomato plants raised in a climate chamber with green light only (from LED lamps) stretched more and had larger leaves and a more open leaf structure than plants grown in white light. Strikingly, this effect was comparable to that of extra far-red light.

In a follow-up trial at Wageningen UR, the plants were lit with green light in addition to natural daylight. In this case too, they stretched more and showed

an open leaf structure. Conversely, it seems that plants exposed to less green light stay more compact. This effect has been confirmed in small-scale trials with the new ReduFlex Green coating. ReduFlex Green selectively allows grow light (PAR light) through while partially blocking the green part of the light spectrum. Therefore, plants under a greenhouse roof coated with ReduFlex Green get less green light.

Following the initial trials at Mardenkro, the plant breeder Florensis tested different ways of inhibiting stretching in bedding plants. In terms of size, the young plants grown under glass treated with ReduFlex Green were found to be between the untreated, neutral control and plants treated with Alar (containing the active ingredient daminozide).

In the Florensis trial ReduFlex Green was able to reduce the use of chemical growth regulators.

Alternatives to growth regulators

The market wants nice, compact plants, but many crops start stretching naturally when they come into flower. Bedding and potted plants, but also cut flowers, are therefore often kept compact with several treatments of growth regulator. However, the use of growth regulators is under pressure, making the search for alternatives all the more urgent.

UV blocking coating trialled in response to market requests

UV radiation can have both positive and negative effects. Prompted by requests from rose growers in Latin America, Mardenkro has tested a removable UV-reflecting coating: ReduFlex UV.

About 4% of sunlight consists of UV radiation. This radiation is invisible but it has a significant impact on the crop. It is usually divided into three bands: UVA, UVB and UVC.

UVC (100-280 nm wavelength) is absorbed by the ozone layer around the earth. This is very fortunate, given that this type of UV light is extremely harmful, damaging cell components and DNA. UVB (280-315 nm) and UVA (315-400 nm) are responsible for the degradation of plastics, which is why it is necessary to protect greenhouse film and plastic panels by adding UV stabilizers. UVA and B mainly influence the shape and color of plants. A small amount is also used for photosynthesis.

ReduFlex UV

Rose growers in Latin America with plastic film greenhouses got in touch with Mardenkro when they noticed that excessive levels of UV light were causing black spots on their flowers. New films can be supplied with an optional UV blocker but this breaks down over time, leaving the crop exposed to UV



radiation. Many growers are located in high-altitude mountain regions of South America, where the temperature is manageable but solar radiation is very high. Mardenkro responded by developing a special coating that blocks UV radiation while allowing as much light through as possible. The first trial results showed positive results and the problem of blackening was visibly reduced. The growers no longer had to protect the flower by placing a protective netting on on each of the buds at an early stage and remove it at time



Growers have to use flower nets to protect their roses.

of harvesting. This can result in major labor savings. It is expected that the new coating also extends the life of the plastic film. The UV blocker is a specialty development in the ReduSystems range and is soon to be trialled by other growers as well.

APPLICATION



Use of ReduSystems

The proper application of a ReduSystems product partly determines if it achieves its desired effect. Many factors affect the final coating that forms after drying.

In the following articles we describe these main factors with the aim of allowing users to obtain maximum benefit from the properties of the ReduSystems products.



Various methods

Application with a spray gun

Most ReduSystems products are excellent for applying manually. The quality and features of the equipment largely determine the end result. Logically speaking a spray gun set should comprise preferably a diaphragm pump with a minimum capacity of 40 l/min and sufficient hose length to reach every corner of the greenhouse. Spray guns are available in different shapes and forms.

The challenge with manual spraying is to evenly distribute the selected number of buckets over the surface. Achieving uniform distribution can be difficult if you don't have any experience.

In practice the balance between the speed of walking, the dilution of the spray solution and the settings and specifications of the spray set determine the properties of the coating applied. If the total surface area is 'hit' in the correct way, the spray solution will flow into a homogenous layer.

When excessive loss occurs as a result of it running into the gutter, the final coating on the roof will be thinner. A thinner layer is less resistant to wear and doesn't produce the effect intended when the solution was selected.

When the operator has insufficient experience with working with a spray gun it may be better to apply one or two extra buckets in order to compensate for the loss of spray solution.



Pump set for manual application

Application with a machine

Application with a machine, suited for the greenhouse structure, is always preferred because it efficiently achieves the best (quality) layer. And the equipment is designed to exactly suit the product.



Top Cleaner Poly as a spraying machine

Advantages of applying ReduSystems products with a machine:

- Nice and even spraying; the coating is applied equally thick
- No loss of product through excessive spraying
- Flexibility; it's possible to only coat one side of the greenhouse
- Less dependent on weather conditions than when using a helicopter or light aircraft
- Savings compared with manual application; without any losses, spraying saves up to 10%
- The ability to brush beforehand guarantees optimum light transmission and better adhesion to the roof
- Machine application is a very safe way of working



Application with a helicopter or plane

When using this method you are dependent on the expertise of the pilot. The quality and level of maintenance of the technical equipment is also a determining factor. This method of application is generally used for large areas of greenhouse roofing. In those cases this method can be very cost efficient.

Points to consider for obtaining the best result:

- 1 It is virtually impossible to obtain an absolutely even layer because the spray formation consists of small droplets. To achieve as uniform a layer as possible the pilot will have to fly over multiple times. That increases the risk of ending up with a layer that is too thick.
- 2 The number of buckets required for the desired effect on the climate is sometimes higher than with other methods of application due to the non-uniform application and loss of product (spraying is less focused so the greenhouse structure and direct surroundings are also hit).
- 3 A non-uniform layer (drop pattern) is in principle not worse. However, the effect of ReduSystems products that have diffuse-causing or spectrum-filtering properties is less. For these reasons this application technique works best when applying ReduSol.



Watch how our coatings are applied around the globe:

[Redusystems.com/video](https://www.redusystems.com/video)

Always a clean greenhouse

CONSULTANCY Even when profit is low few companies cut back on cleaning the inside and outside of the greenhouse. This indicates that in practice the importance of good light transmission has sunk in.

Contractor De 3 Koningen (The Three Kings), of Steenberghe, the Netherlands, specialises in cleaning. This particular company name was chosen when brothers René and Frank de Koning (King) joined forces with their younger brother Robert. The company also has five permanent employees and when necessary takes on temporary personnel.

"We recommend that vegetable greenhouses, the segment in which we by far the most work do, are cleaned three times per year. Some vegetable greenhouses even clean four times per year. The realisation that glass should be clean the entire year round is becoming more and more noticeable," says René de Koning. That includes flushing out and cleaning the gutters because these can also cause the glass to become dirty again.

Roof washers

Many large greenhouses have their own (stationary) roof washer. However, De Koning notices that some growers are moving away again from self cleaning. "Their machines often lie idle for quite some time, such as during the sum-

mer. This standing still combined with lack of maintenance means things can go wrong. Such growers then call us, either to do the maintenance, or to take over the entire cleaning with our well-maintained machines. These have improved a lot over the years and now have wider brushes and double gutter brushes."

"Another branch of the business is cleaning the inside of greenhouses in between the old and new crops."

De 3 Koningen has four large roof cleaners (4 metres wide) and a smaller one (3.20 m). Annually these are used to clean some 4 million m² of greenhouse roofing. In addition to the normal cleaning the company can also remove ReduSystems coatings with ReduClean. The contractor is also increasingly asked to apply coatings at the beginning of the season. Due to the structure of its customer base (mostly vegetable growers), this is usually ReduFuse.

Crop change over

Another branch of the business is cleaning the inside of greenhouses in between the old and new crops. During a six week period they clean some 250 ha. "This is a very busy period in order to get everything planned in.



Many greenhouses change crops at the same time. In order to get everything done we then work through the weekend," he says.

First the whole greenhouse is sprayed using radio-operated spraying vehicles. Then the greenhouse is sprayed again, this time manually using a hydrocart. "We notice that GS-4 is used more and more often. We used to think that

you needed a very aggressive fluoride substance but we now realise that the greenhouse can stay clean with environmentally friendlier substance, such as GS-4. Therefore some customers no longer want to use aggressive substances due to the vapour given off and its risk to humans and the crop. Sometimes it's necessary to use a little more on the walls and this works perfectly."

Diffused glass and AR-glass: To coat or not?

KNOW-HOW Diffused glass and AR-glass are becoming increasingly interesting for vegetable growers, sometimes in combination with one or more screens. Is a coating then necessary? That depends on several factors, including the type of glass, the crop and the region. In many cases a coating is still a good option in summer in order to keep the heat out of the greenhouse and to ensure that the crop keeps growing.

Not all Dutch vegetable growers use a coating in the summer. Nevertheless, there are enough reasons to do so. In some crops, such as highwire cucumbers and the smaller tomatoes types, a coating is often applied to maintain crop growth and to avoid it becoming too generative. Other reasons are applicable to sweet peppers: a coating can prevent problems with fruit setting, fruit burn and blossom end rot. For this purpose ReduFuse is the most commonly used solution.

Coating diffused glass

In practise, growers with diffused glass on the roof also use an additional liquid coating. If the glass does not have an factory anti-reflection coating, all ReduSystems coatings can be applied to this glass type. However, more attention is required during its removal to ensure that no remnants of coating remain in the coarse structure of the glass.

Coating with AR-glass

With AR-glass it depends on the factory

anti-reflection-coating as to which product is best to use. Some AR-coatings allow more infrared light to pass through than others. The more IR-light that the glass allows through, the more important the heat reflecting ability of the coating becomes. In most cases ReduHeat or ReduFuse IR are the most suitable for this, certainly in southern European countries. However, some glass manufacturers don't recommend the use of liquid coatings on diffuse glass or AR-glass, and its usage can lead to loss of warranty. If in doubt, check with your glass supplier and/or Mardenkro.

“If the glass does not have an factory anti-reflection coating, all ReduSystems coatings can be applied to this glass type.”

Coating and screens

Growers using diffused glass or AR-glass in combination with one or more shade screens are advised to apply the coating more lightly. Shading with screens by themselves is often not enough because too much heat enters the greenhouse. Growers without a screen will have to apply the coating more heavily but this is at the expense of light in the morning and evening. Combining a coating with one or more screens often works best. That is not only more pleasant for the crop, but also for the employees who work in the greenhouse.



Removing coatings: how to get your greenhouse spotlessly clean

KNOW-HOW This summer, some growers have started removing their greenhouse roof coatings earlier than usual because of the mediocre summer weather. ReduClean is the perfect product for the job. When it comes to removing ReduFuse (IR), there is a special version of ReduClean available: ReduClean for ReduFuse. Dennis van Veldhoven, co-owner of machinery contractors Van Veldhoven in De Lier in The Netherlands, explains how to get the best result.



This summer, some rose and vegetable growers started removing the coatings from their greenhouse roofs as much as ten days earlier than last year. “The season doesn’t usually start until mid-August, but we’re already working on it now,” reveals Dennis van Veldhoven, just back from his summer holiday. This summer looks set to be a repeat of last year’s, although it could still turn warm and dry in September. But that would present him with a new challenge, because a heavy rain shower is needed to rinse off the coatings. And if the rain stays away, he will have no choice but to spray the roof again. “So we’re constantly checking the weather on five or six different weather apps. Although they aren’t always accurate anyway. A thunderstorm can be very localized, which can make things quite difficult. Sometimes I feel like one of those TV weathermen. So it’s a constant stop or go situation for us.”

Weather forecast

Removing coatings therefore starts off with the right weather forecast. “You need dry weather to apply ReduClean, ideally for a couple of hours.” This time is needed to allow the remover to react properly with the coating. After that, you need a good downpour within the next two or three days, because if the rain stays away for much longer the glass may not come completely clean.

ReduClean is the perfect product for coatings like ReduSol, ReduHeat and ReduFlex Blue. For a special coating like ReduFuse (IR), you’ll need a stronger product: ReduClean for ReduFuse. Dennis: “White chalk products can wear

off, particularly with the heavy downpours we have been getting lately. But diffuse coatings are extremely rain-resistant, so you need a stronger product to remove them. ReduClean for ReduFuse (IR) works really well. It leaves your greenhouse spotlessly clean after a good downpour. But you do have to make sure you cover all the coating when you spray it on.”

“Removing coatings therefore starts off with the right weather forecast. You need dry weather to apply ReduClean, ideally for a couple of hours.”

Conditions

To ensure even distribution, the greenhouse roof must be dry, the machine must be properly adjusted and the product should be diluted in a ratio of between 1:5 and 1:7, Dennis says. “We always ride along with the sprayer on the roof so that we can intervene straight away if a nozzle gets blocked. It all has to happen very quickly because the vents have to be closed, of course. And you can’t leave them closed for too long, otherwise you risk damaging the crop. With an ideal gutter length, we can do 1.5 hectares in an hour. Most growers therefore prefer to outsource the work, although a few still do it themselves.”

RESEARCH



Miles ahead in innovation

ReduSystems products are world leading. Mardenkro has been miles ahead in innovation for many years now, and that has been recognized: our products have won several innovation awards at leading international trade fairs.

Our R&D department has shifted into an even higher gear, resulting in a wider range of innovative products. To achieve this we are working intensively with some of the world's top research centers, universities and growers. All of our products undergo rigorous independent scientific testing which demonstrates that they deliver clear added value in the greenhouse.

There's still lots more we can do with light

Mardenkro's extensive laboratory facilities are one of the cornerstones of ReduSystems. It is here that ideas for new applications and suggestions from growers are transformed into new innovative coatings. Quality control is another important task for the laboratory. No coating leaves the premises without being thoroughly checked.

Every innovation starts with a good idea, whether you're "translating" developments in another sector, trends in the market or suggestions in a research report. The initial idea is followed by a long process of exploring the possibilities, developing prototypes,

testing, continuing development work, conducting trials on a small and larger scale, and carrying out field tests. R&D Manager Roel Weijers explains: "This kind of exercise involves testing dozens, sometimes hundreds of formulations. Many of these don't bring immediate results but may be useful in the longer term. We still have a lot in the pipeline." Broadly speaking, there are two sources of innovation. Weijers again: "Trends in the horticultural market provide us with new avenues to explore. For instance, when it was scientifically proven that diffuse light is beneficial for plant growth, we got straight to work. Another source of ideas is developments in raw materials, which we keep a close eye on through our extensive network."

Ever-growing product range

New products have been added to the Mardenkro range at a rapid pace in the past few years. These include solutions that reduce light loss caused by condensation, such as AntiCondens for Glass, and solutions that increase light transmission, such as AntiReflect.

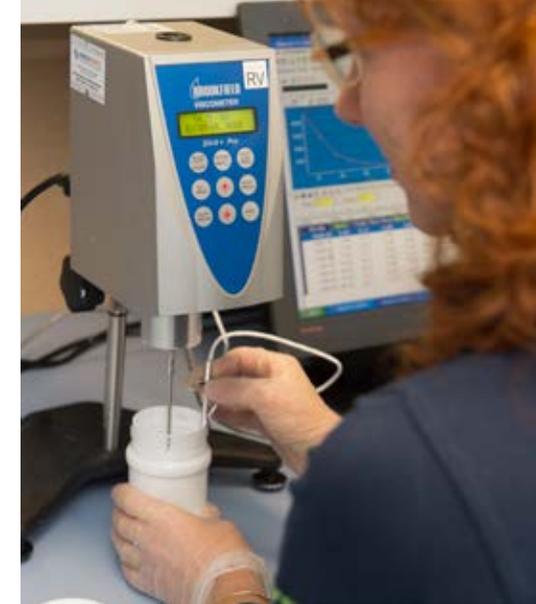
ReduFlex Blue, ReduFlex Green and ReduFlex UV are examples of coatings that change the color spectrum of the incoming light. "We used to be known as a manufacturer of light-reflecting coatings," says Weijers. "We have also branched out into other areas, including diffuse coatings. But for a while now we've been working on the idea of actually improving light transmission. In moderate climates, light is the limiting factor for production in winter, so every little bit of extra light in the greenhouse translates into profit."

AntiCondens for Glass turns droplets of condensation on the greenhouse roof into a thin film of water, allowing significantly more light through than with untreated glass. AntiReflect ensures that less sunlight reflects off the greenhouse roof, thereby also increasing transmission. "Nowadays, an AR solution is often applied to greenhouse glass in the factory," Weijers points out. "But there are still a lot of greenhouses that haven't been given this treatment. In that case, our AntiReflect solution is a good way of improving transmission."

Independent measurements

Most new products are thoroughly analyzed and tested in the Wageningen University & Research LightLab. All product specifications are therefore based on independent data. The results of LightLab tests and measurements are regularly published in our newsletter and on the ReduSystems website.

A comprehensive quality control system ensures that the properties of each coating meet the specifications. Weijers



outlines the procedure: "We rigorously check the properties of all incoming raw materials. After it has been processed we also check the intermediate product. Finally, we sample each batch produced for quality control purposes. Depending on the product, the samples are kept for one or two years."

"Trends in the horticultural market provide us with new avenues to explore."

Smart materials

Looking to the future, the development work will continue apace. "There's still lots more we can do with light. For instance, we're taking part in a project on smart materials with Wageningen UR and Eindhoven University of Technology. It involves exploring and developing technologies with the aim of creating the greenhouse roof of the future."

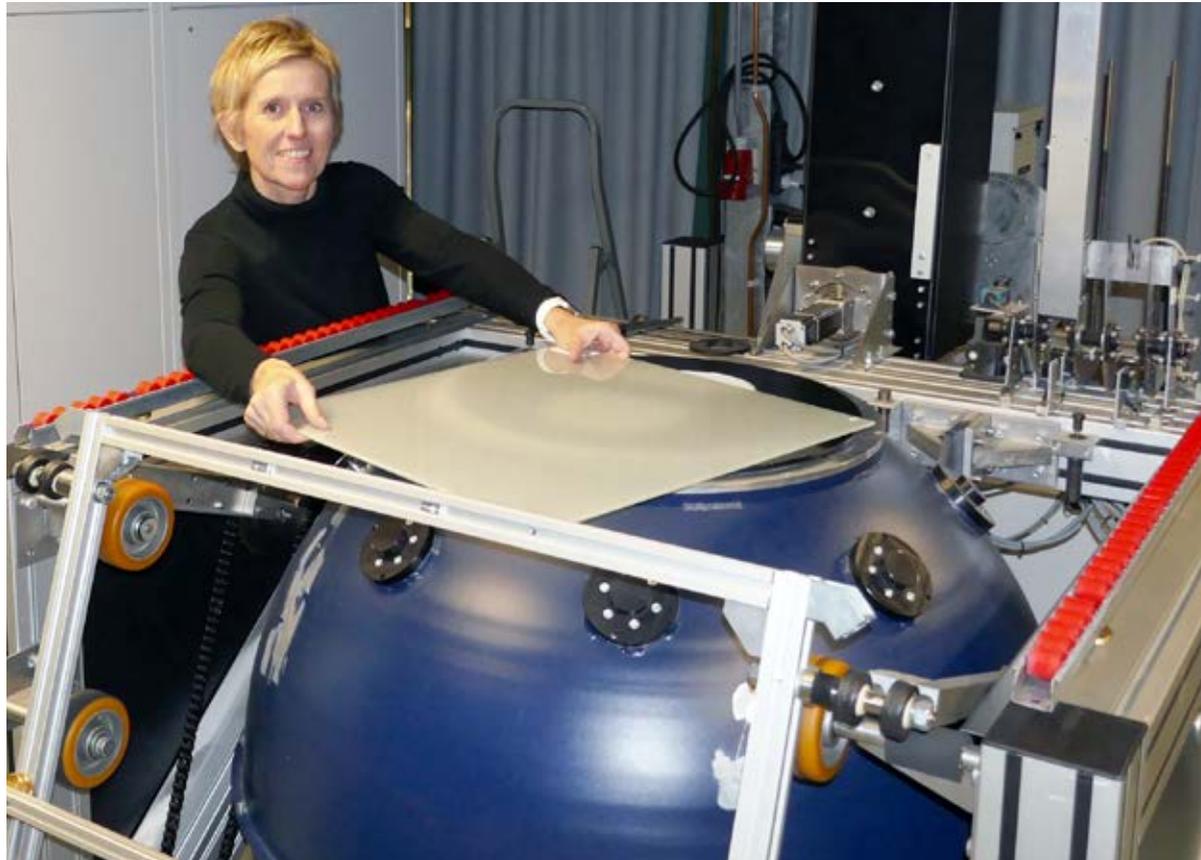


The importance of reliable and independent measurements

Mardenkro is firmly committed to ensure that its products have a sound scientific basis and therefore maintains close contact with Wageningen University & Research, the perfect partner for conducting independent measurements and pursuing new avenues.

Measuring accurately is an art. Two measurements performed on the same material under the same conditions have to produce the same results. And if you want to compare materials, you need a measurement protocol in order to make any reliable claims. The LightLab at Wageningen University & Research specializes in this area.

Silke Hemming, head of Wageningen UR's Greenhouse Technology research team: "We're seeing that manufacturers of light-transmitting materials are developing their own measuring methods. These can be very sound and consistently reproducible. But the drawback is that the results can't be compared with those of another manufacturer that uses its own measuring method. Comparison is only possible when a uniform measurement protocol exists. Another important factor is that an independent authority should carry out the measurements, and not the manufacturer itself. Independent uniform measurement protocols improve the quality of



the entire horticultural sector."

Condensation

Developed by Wageningen UR in consultation with growers, the new Dutch standard (NEN 2675) on light transmittance and scatter through greenhouse materials will come into effect in early 2018.

Since technology is continually evolving, measurement protocols and NEN standards become obsolete. And sometimes there is not even a protocol in place yet. "A good example is conden-

sation on materials," Hemming adds. "We're currently devising a method for this. To introduce a new protocol, there has to be a need for one in the sector, and it has to be generally accepted as the standard."

In some cases a standard does exist, but for another industry. One example is the standard for material aging. "There is a standard for this in the solar industry, but aging conditions are completely different in greenhouses, where humidity is high and chemicals are used. Although the influence of UV radiation is comparable, the existing solar standard doesn't go beyond the first three years – yet a greenhouse can last for at least 15 years. We are working with the TÜV Nederland technical inspection service on adapting the standard to make it suitable for the horticultural sector."

AntiReflect

Mardenkro has many of its products analyzed at the LightLab in Wageningen. In the case of coatings, the measured values depend on the coating thickness, which is therefore standardized as much as possible. With new products, such as AntiReflect, for instance, treated window panes from greenhouses are also sent to the lab. The growers then receive a report on the results.

The LightLab is a world leader in reliable measurement of greenhouse materials. The number of properties the lab can measure is constantly growing: transmittance of light at different angles of incidence, the spectrum of the transmitted light, haze and scatter, emissivity and reflection, condensation,

aging, and air permeability of materials (e.g. screen fabric).

Ray tracing

Besides measurements, Mardenkro also calls on Hemming's research group for calculations. One example was an initial assessment of the effects of AntiReflect using the ray-tracing and Intkam computer models. "Field data is constantly fed into these models to further validate them," Hemming explains. "Ray tracing, which follows the path of a beam of light as it travels through a material, is commonly used in our Winterlight greenhouse, for instance. First we did the calculations, then we built small scale models of the greenhouse, and finally the greenhouse itself. These calculations between the model and the actual measurements we make in the greenhouse appear to correspond."

Wageningen UR is constantly seeking to optimize greenhouse materials and climate control. This leads to new types of greenhouses, which are gradually being adopted by the industry and actually compete with coatings. "In the future, growers will need to weigh up the cost of investing in an expensive greenhouse or optimizing their greenhouse climate with coatings instead," Hemming points out. "The big advantage of coatings is that they are very flexible and can be used in existing greenhouses. This means that they have a bright future. The sustainability requirements for coatings are also likely to be tightened up at some point in the future, however."

Smart materials

Mardenkro is a member of the Club of 100, a group of leading horticultural suppliers that co-finance and support the horticultural research carried out at Wageningen UR.



The group is involved in pre-competitive projects, one good example being Smart Materials for Greenhouses. Hemming again: "In partnership with Eindhoven University of Technology and companies like Mardenkro, we are researching materials that self-adapt to changing conditions. They might become darker or more diffuse in stronger sunlight, for instance."

Her group also conducts business-to-business research for individual businesses. "The results are only shared with the client, of course. Even with this kind of research, we retain our independence. We adhere to the Netherlands Code of Conduct for Academic Practice, which upholds the principles of scrupulousness, verifiability, impartiality and independence. That, too, is in the interests of quality in the horticultural sector."

"The big advantage of coatings is that they are very flexible and can be used in existing greenhouses."

Improve plant shape with light strategy

KNOW-HOW The quality of flowers and plants is, among things, determined by their shape and compactness. Many ornamental crops in greenhouses exhibit too much stretch. Therefore, to achieve the desired, uniform shape, growth regulators are used.

Several ornamental crops can't be grown without growth regulators. These include: poinsettia, bedding plants, kalanchoe and certain types of (potted) chrysanthemums. However, the use of chemical products is increasingly under discussion based on environmental concerns. In the coming years research will focus on alternative methods to achieve compacter plants with less or even no use of chemical regulators.

Many factors influence the compactness of plants such as light intensity, light colours, temperature (regime), movement of plants and breeding. Breeding companies are increasingly able to improve the plant shape. Then the use of regulators can be significantly reduced which, besides environmental benefits, also leads to greater cost advantages due to less spraying.

Steering plant shape

During the last few years research has been focusing on the ability to improve

plant shape with light. Visible light comprises a spectrum of colours. Over the course of a day and over a year this spectrum is reasonably constant. Nevertheless, during the summer there is, relatively speaking, slightly more blue light. At sunrise and sunset the amount of red light is slightly less than that of blue or far red light. This effect is greater on cloudy days.

"By changing the relationship between the light colours it is possible to influence plant shape."

By changing the relationship between the light colours it is possible to influence plant shape. Research in climate chambers has shown that relatively more blue light in relation to red light produces a more compact plant. Also the ratio of red:far red is an important factor in the length of a plant. The more far red light the more a plant stretches. So if we want to influence the compactness of plants by means of light colours, we will have to increase the blue:red ratio and the red:far red ratio.

Other relationships between light colours, however, have other effects on

the plant. A relatively high amount of blue light produces more branching, less leaf surface area and biomass but thicker leaves so it doesn't have any effect on photosynthesis. Also, several studies have shown that stomata open further under the influence of blue light so that transpiration increases and leaf temperature may decrease. In addition, changes in colour ratio can affect the number of flowers and the flowering time.

Influence of the light spectrum

We can alter the light spectrum in several ways. These include artificial lighting with specific colours, coloured films, shade screens and photo selective coatings. Lighting is mostly applicable during periods when the radiation is low. It will require a huge amount of lighting capacity to sufficiently alter the colour ratio in the summer months. An option could be to light with extra blue light in the dark-hours but whether this has sufficient effect is not yet known. It is possible to supply extra light during the morning and evening hours by using, for example, SON-T lights to influence the red:far red ratio. SON-T lights radiate a relatively high amount of red light compared with far red light so that stretching is slowed down.

Films are available on the market that change the ratio of red:far red. The film absorbs the far red so that relatively more red light enters the greenhouse that again leads to more compact plants.

Especially in the summer months it is possible to influence the light spectrum by using shading screens and coatings. One coating that alters the ratio of red:far red is ReduHeat. This is a coating that allows the maximum amount of PAR light to enter while shading out comparatively more infrared light. Research has shown that different types of potted plants clearly remain more compact when using ReduHeat (J.O. Stapel et al, 2009). For many plants this effect is still not sufficient to obtain the desired compactness in the plants. The goal is to develop coatings that have a greater impact on compactness. However, it is impossible to achieve this by only using a coating. Mardenkro is working with research centres and suppliers, for example of shade screens and greenhouse films, to develop cultivation strategies in which chemical inhibition is (almost) no longer necessary.

“Especially in the summer months it is possible to influence the light spectrum by using shading screens and coatings.”



Adjust the irrigation under a coating

KNOW-HOW A coating on the roof has consequences for the water management. Jos Beerens of Grodan explains what the grower needs to bear in mind.

The greenhouse climate and the crop mutually influence each other. Light and temperature also play an important role. Because both these climatic factors are affected by coatings, the plants also function differently. This is also the intention of the coating. It makes sense to also consider this when irrigating the crop.

"It's not about making large adjustments, but improvement return on investment often lies in the detail: adjustment of start and stop times of the irrigation regime and the light intensity at which you are going irrigate," says Beerens, business support manager for Rockwool supplier Grodan.

He says that the influence of irrigation



as a control instrument is often underestimated. "Coatings that block light often make the crop more vegetative. The response to irrigation must then be to steer towards generative growth, for example, by allowing the water content to drop some more after sunrise, before the irrigation begins."

Solar protection

Coatings are divided into those that protect against sunlight, those that protect against heat and the diffuse types. Under a coating that blocks sunlight, such as ReduSol, the plant receives less direct light. "That makes a difference especially in the morning and evening," says Beerens. "It means that generally a grower should irrigate later than when there is no coating. It is important to realise that a solarimeter outside the greenhouse (which measures the sunlight) is then no longer completely reliable as a tool. You need to set the light intensity at which you start irrigating higher or measure the light in the greenhouse. A coating that reflects sunlight therefore has consequences on the start and stop times of the irrigation regime and the light settings in the computer."

He points out that it is also possible to control the water content in the slab. The response by the plant to the climate has direct consequences on the water uptake. Grodan has developed the GroSens system so that a grower can measure the level of water in the slabs at several places in the greenhouse. Taking a measurement at just one place is not representative enough.

Prevent heat stress

A heat reflecting coating, such as ReduHeat, blocks the heat radiation (infrared) but lets virtually all the PAR light through. That prevents the crop suffering heat stress. Beerens: "You should keep in mind that the crop heats up less quickly in the morning. It might be necessary to compensate for that by using additional pipe rail heating. And attention also needs to be paid to the water supply; this takes longer to get going in the morning. In the middle of the day at higher light intensities (> 700 watts) the plant suffers less stress under ReduHeat, meaning that it can take up more water than when there is no coating. Therefore it is often possible to irrigate longer at the end of those particular days."

Diffuse coatings, such as ReduFuse or ReduFuse IR (which also reflects heat), ensure better light penetration in the crop and less stress. This means that the crop is often much more active and therefore transpires more. "The water uptake is then greater and it is very useful to keep an eye at which moment this increases. In general, you will need to irrigate longer under a diffuse coating. Normally less drain is needed (< 20%) after 3pm. But if the crop remains active longer, reducing the water content, you can still give an extra irrigation cycle."

Decrease in water content

He notices that crop advisors remain on the side of caution and often prefer to advise 10% more drain than is necessary. "We like to monitor the radiation (drain % = radiation sum day/100) and the decrease in the water content

of the slab during the night. The goal is a reduction of 8 to 10%. If this is not achieved you need to figure out why not. Is it due to stopping too late or starting too early? Is the climate too passive? And why is that: too much screening or because the heating is turned off too quickly? Every grower needs to be conscious of this and take into account how the coating influences the crop. All crop consultants visiting the greenhouse should be informed that there is a coating on the roof so that they can take it into account when giving advice.”

“A heat reflecting coating, such as ReduHeat, blocks the heat radiation (infrared) but lets virtually all the PAR light through.”

Finally, he says to pay attention to the EC of the nutrient solution. If the plant, for whatever reason, takes up less water, it also receives fewer nutrients. “Then you have to adjust the EC and be more critical about reducing the EC based on light quantity. We are not talking about any mistakes but just things that can lead to improvements. The water content and the EC during the day indicate if the plant is feeling comfortable or if something needs to be adjusted.”



Reducing UV with ReduFlex UV

UV radiation can have both positive and negative effects on the crop. A high dose is not desirable however, it inhibits photosynthesis and results in visible damage. In addition, UV radiation breaks down plastics. ReduFlex UV is designed to protect against excessive doses of UV light.

About four percent of sunlight consists of UV radiation. This radiation is invisible but it has a significant impact on the crop. It is usually divided into three kinds: UVA, UVB and UVC. UVC (100-280 nm wavelength) is absorbed by the ozone layer around the earth. UVB (280-315 nm) and UVA (315-400 nm) are responsible for the degradation of plastics, which is why it is necessary to protect greenhouse film and plastic panels by adding UV stabilizers. UVA and B mainly influence the shape and color of plants. A small amount is also used for photosynthesis.

Better resilience

For a long time it was thought that UV radiation simply damaged the crop. But in low doses it stimulates the formation of beneficial substances and improves resilience to pests and diseases. Ordinary greenhouse glass keeps out most of the UV radiation, but this may be one reason why plants grown in glass greenhouses show lower resilience. Also worth noting is that UV light helps create compact, well-branched plants with better color.

But that's not the case with high doses of UV light, which occur in countries with bright sunlight and especially at higher altitudes. Then a whole range of damages can occur: growth inhibition, deformities, leaf curl, reduced fertility, and even damage to DNA.

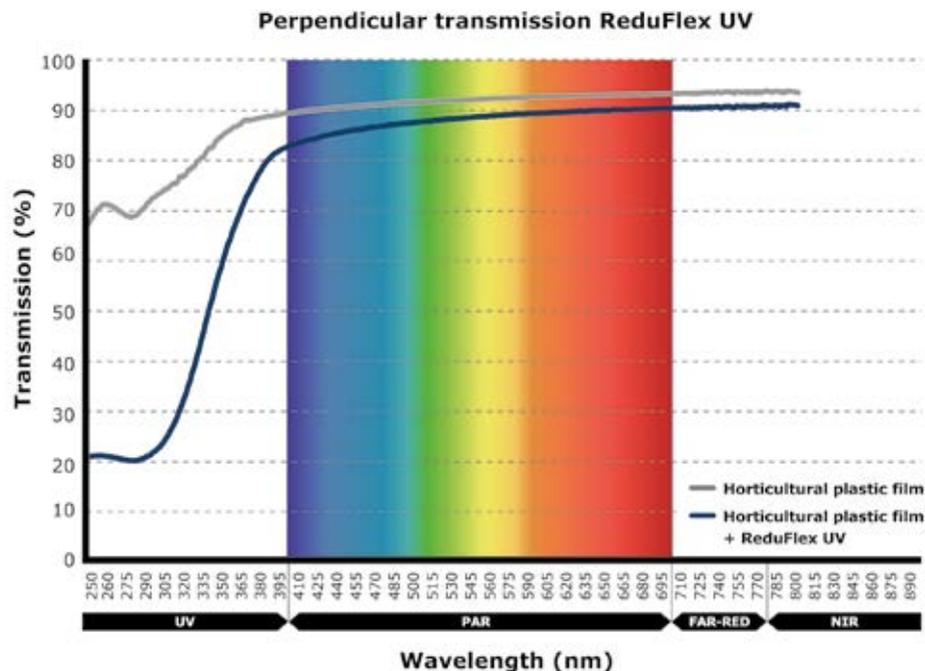
“Plastic greenhouses allow relatively more UV through, depending on the composition of the film.”

Reducing UV transmittance

Plastic greenhouses allow relatively more UV through, depending on the composition of the film. To prevent this and to stop the plastic from degrading too fast, manufacturers often add a UV blocker. But this breaks down over time, leaving the crop to cope with ever higher levels of UV radiation. It may therefore be necessary to reduce UV transmittance, either all year round or at a particular time of year. ReduFlex UV does just that by letting PAR light through and only blocking UV, especially UVB.

On the other hand, it is important not to screen out too much UV as this is known to impact on plant resilience. So it may be necessary to remove the coating again in the rainy season in or-

der to get enough UV coming through to the crop at this cloudy time of year. This also helps protect against diseases like mildew.



CONSULTANCY

A photograph of two men in a greenhouse. The man on the left is bald with a mustache, wearing a grey polo shirt. The man on the right is seen from the back, wearing a white long-sleeved shirt with the ReduSystems logo on the back. They are standing in a greenhouse with rows of plants and hanging lights.

Technical support

Every greenhouse is different. With our wide range of ReduSystems products, we are able to offer tailor-made solutions for all seasons anywhere in the world. Our in-house consultants can advise on which coating to choose and can work with the grower to create a light plan that is perfect for their situation.

We also work actively with an international network of independent crop consultants to provide high-quality product support in all areas.

Link between R&D and practice

CONSULTANCY The role of Mardenkro's Horticultural Product Specialist revolves around taking the latest technologies from the lab to the market. Important activities include giving advice, carrying out trials and providing guidance during application. On the other hand, the specialist also plays a role in translating growers' needs into product development.

The right choice

ReduSystems coatings are all fully compatible and therefore easy to combine. A customized solution can be found for every situation. But it can sometimes be tricky to choose the right coating or sequence of coatings and to get the timing right.

Good advice can be obtained from the online ReduWizard app, which can be found on the ReduSystems website and recommends the best coating to use depending on the crop, the region and the features of the greenhouse. The account manager or local crop consultant can also provide targeted advice. In special cases, our Horticultural Product Specialist Hans van Eijk is your man. Hans is responsible for knowledge development and sharing.

Custom advice

ReduSystems products can greatly improve the plant's performance in every situation, in every crop and in all seasons. The right choice of coating or a combination of different coatings can help maximize production and qual-

ity. Custom advice always produces the best results because it enables the grower's specific requirements to be accommodated.

"The right choice of coating or a combination of different coatings can help maximize production and quality."

Close contact with research

The product specialist keeps in close contact with the world of research. Wageningen University & Research (UR) is one of our most important partners: all ReduSystems products are analyzed and tested in the Wageningen UR LightLab. Van Eijk: "We have all our products thoroughly tested by an independent institute before being sold. That way we can always provide reliable information on the effect each of our coatings has. The Wageningen UR LightLab specializes in testing glass panels coated under practical conditions, which minimizes the risk of surprises in the greenhouse setting."

In addition, Mardenkro is a member of the Club of 100, a group of leading horticultural companies that co-finance and support the research carried out at Wageningen UR. "This enables us to keep up with the latest developments and translate new scientific findings into practical applications at an early stage," van Eijk explains.

One of the latest findings is the influence of the light spectrum (the color of the light) on crop growth and development. Scientific knowledge in this field is still expanding, and ReduSystems is responding to the new opportunities for steering the crop with its ReduFlex line.

Practical trials

Van Eijk: "My role is essentially that of a link between R&D and practice. When we launch a new product we always start by running small-scale trials with growers. If they go well, we upscale to bigger practical trials. With growing numbers of development projects ongoing, Mardenkro is running more and more practical trials, and coordinating them all meticulously is now a permanent part of the product specialist's role. We publish the results of these trials in our newsletters and discuss them with crop advisers, consultants and horticulturalists so that we can keep them up to date with the latest developments."

Van Eijk also keeps a close eye on trends and issues on the ground. Mardenkro can adapt coatings to a particular situation and can respond to developments in the horticultural sector by introducing new products.

Applying coatings

For the best possible result, it is important to apply the coating on the glass evenly. Applying coatings properly is becoming more and more important. With the latest product, AntiReflect, the layer thickness is the key to ensure that the coating works properly. The layer thickness must be exactly right because light gain will be insufficient if the layer is too thick or too thin. Mardenkro has guaranteed a minimum value of 2.5% for AntiReflect, and to achieve this it now certifies contractors before allowing them to apply AntiReflect commercially. In some cases this requires the contractor to fit their spray equipment with a speed and flow meter so the application rate is displayed constantly on a computer. This ensures AntiReflect is applied evenly and enables the contractor to make adjustments straight away where necessary.



Is AntiReflect invisible?
See for yourself in this video.
[Antireflect.com/video](https://antireflect.com/video)

Crop's needs form basis for light plan

CONSULTANCY The wide range of coatings available from ReduSystems enables you to influence the amount of light, the temperature and the color spectrum in the greenhouse all year round. The starting point for a light plan for the whole year is the crop's needs.

The light spectrum runs from UV radiation to infrared light. In between is the PAR light that the plant uses for photosynthesis. Coatings not only influence the amount of light entering the greenhouse but also the distribution of the light and the ratio between the light colors. They also influence the

"The online ReduWizard app on the ReduSystems website, incorporates all these aspects and provides good advice."

temperature in the greenhouse. With so many options, how can you come up with an effective light plan for the whole year?

"The starting point is the daily light integral (DLI) that the plant needs," says Hans van Eijk, Horticultural Product Specialist. "Crops differ greatly in the extent to which they can exploit the light. Bromeliads, for example, can only use 5 moles of photons (light particles)

per square meter per day. Roses and tomatoes can handle more than 20 mol/m²/day. If you know the crop-specific DLI value, you can compare it with the development of the amount of natural light during the year. Then you'll know when there is too much or too little light."

Clean greenhouse roof essential

In the months with too little light, the light transmittance of the greenhouse roof must be as high as possible. A thoroughly clean greenhouse roof is key, and that can be achieved with a product like GS-4. In addition, AntiCondens and AntiReflect allow more light into the greenhouse.

In months with far too much grow light, light-reflecting coatings can be a solution. However, there are many situations in which the use of the available light can boost yields if it is better distributed. If the top of the plant has already received too many photons, leaves at the bottom can sometimes still absorb quite a bit. The solution then is to make the light diffuse using a product like ReduFuse or ReduFuse IR.



Crop consultant Wim van Wingerden explains the possibilities of steering the crop towards generative or vegetative growth:

[Redusystems.com/wim](https://redusystems.com/wim)

"But it is not only the DLI that is key: the photo response curve also plays a role," says van Eijk. "When the light level rises, the crop can make efficient use of the light to begin with. But the efficiency decreases at a higher level, and if light levels rise even further the efficiency can decrease even further and damage can occur." (See photo response curve on page 64)

Even if the DLI value of the crop isn't reached any given day, the high light level could still negatively impact the production at some point. That is the second factor that has to be kept in mind when choosing a coating.

The third factor is the temperature. Van Eijk again: "The question is then: how much heat is acceptable? The higher the temperature, the faster the crop will develop, but each crop has its optimal range. Beyond that, growth will be inhibited or damage will occur."

The coating used should come as close as possible to the ideal combination of

temperature, DLI and maximum allowable light level for the crop. This combination also determines whether the coating should reflect both light and temperature or just temperature. ReduSol is an option in the first instance and ReduHeat or ReduFuse IR in the second.

The fourth factor is light color, which influences the development and shape of the crop. ReduFlex Blue produces longer stems in certain rose varieties, for example. This also has to be factored into the light plan.

The online ReduWizard app on the ReduSystems website, incorporates all these aspects and provides good advice. If you want to create a light plan with one of the ReduSystems coatings or a sequence of different coatings, your Mardenkro account manager will be happy to help.

Every situation requires a different solution

CONSULTANCY Consultant Carlos Jansen of Delphy advises tomato growers in western and southern Europe. They are all growing the same crop, but conditions vary greatly: maritime-influenced climate, continental climate, Mediterranean conditions. Mardenkro's wide range of coatings enables him to recommend a tailor-made solution for every situation.

Dutch horticultural knowledge is sought after worldwide. Dutch consultancy Delphy's website is now available in ten languages. "Growers don't only call on us for our knowledge of growing but also to keep up-to-date with the latest developments," says Carlos Jansen. "But the Dutch approach can never be adopted one-to-one; you always need to adapt the insights to the conditions and situation in the region."

Jansen also believes that Dutch growers can learn a lot from their international colleagues: "In crop protection, for

instance, some growers are more advanced than their Dutch counterparts. And sales are also often organized better than in the Netherlands," he says.

Understanding the role of light

His role as a consultant is to prevent problems and provide advice in acute situations. This could be on anything from the climate strategy, the irrigation strategy, fertilization and interpreting the condition of the crop to brainstorming with the grower about strategic choices.



Scientific understanding of the relationship between light and how the plant works has increased hugely in the past ten years. Growers are keen to apply this knowledge in their own greenhouses, for instance by making better use of the available light rather than screening it out.

Jansen: "Customers in southern Germany grow in a continental climate. They want maximum light utilization, but light is not the limiting factor in hot summers. ReduFuse IR is a good choice in this case. This coating distributes the PAR light, which the plants need for photosynthesis, but keeps out infrared radiation that only heats up the greenhouse."

This advice doesn't apply to everyone, however. "When determining the right strategy, you look at the crop and the variety, the greenhouse (high or low) and even what type of grower the owner is," he says. "Then you can work out the coating (or combination of coatings) that fits their cultivation strategy. In southern Germany it's often ReduFuse and ReduFuse IR, and in some cases ReduHeat. It's mainly about preventing light and heat damage and steering the crop: you don't want it to be too generative. Sweet pepper and cucumber growers in that region tend to use ReduHeat more."

He adds: "Fruiting vegetable crops almost always benefit from diffuse light. The more direct sunlight there is, the greater the effect of a diffuse coating. It enables better horizontal and vertical distribution of the light and prevents sunspots and hard shadows, so the plants don't have to keep adapting to different conditions. What's more, the

head of the plant is less likely to suffer from heat stress and leaves lower down in the canopy can play an active role in photosynthesis and cooling. ReduHeat reduces heat stress, which increases total assimilation."

Mediterranean conditions

For a customer in Greece with a plastic film greenhouse, the situation is completely different. He plants in mid-July and harvests throughout the winter. "Growers in Mediterranean countries often use ReduSol and ReduHeat. My Greek customer uses ReduHeat at the beginning of the crop to protect the young plants from the bright summer sun and removes the coating in around September. The decisive factor is the light sum needed in combination with the 24-hour temperature. Anything above that isn't properly utilized so it can be screened out."

In Mediterranean countries, Delphy often advises consultants of suppliers and auctions. They integrate the knowledge into the advice they provide on cultivation and sales strategies.

"We always tell everyone that it's important to look at each individual greenhouse situation when choosing coatings. With such a wide range of coatings available, we can offer tailor-made solutions, and the results achieved with ReduSystems coatings are always predictable. However, as consultants we always have to point out the correct dosage. You will only get the desired effect if you use the prescribed number of buckets of coating per hectare," he concludes.



Use of coating requires tailor-made advice

KNOW-HOW For every type of crop it is important to create an optimal climate year-round to constantly achieve the maximum yield and quality. A coating on the greenhouse roof can be a good tool for this. However, there is a large range of coatings available and these can also be applied in different thicknesses. So it's important to know what suits your crop, greenhouse and location.

At Mardenkro we greatly value the correct use of our ReduSystems coatings. This started when we introduced ReduSol; together with the grower we figured out what the optimal thickness of the layer (shade percentage) should be and the best time to apply and remove the coating. Over the years many more types of coatings have been added making it increasingly difficult for a grower choosing the right one or how to use them. This was why Mardenkro decided to work more intensively with crop consultants.

After the launch of ReduFuse Mardenkro set up its own consultancy service. In cooperation with external crop consultants this department distributes knowledge about how to use coatings and their influence on climatic conditions in the greenhouse both internally and worldwide. This includes the greenhouse temperature, CO₂ level, humidity and light (amount, light colours, diffusion).

The advice given by Mardenkro reaches all corners of the globe. We have to take into account many different climate conditions worldwide of which each

climate requires a different approach when using the coatings. First we always consider the crop that is in the greenhouse. Each crop and even variety has its own light and heat requirement. To combine all these factors into advice we developed the ReduWizard.

ReduWizard gives you advice about which coating best suits your crop. Based on the extensive climate database that records climate data from thousands of locations around the world, it decides which product is most suitable for your crop, region and greenhouse type.

There are however situations for which the ReduWizard is unable to offer a good solution. For example, for a specific variety of rose, which responds differently to certain light colours, or a tomato crop grown under artificial lights which sometimes requires a certain coating to help it get through the summer. In cases like that you can always contact Mardenkro; together with you, and possibly the crop consultant, we will find the most suitable shading strategy for your situation.

The bright side of growing is a collection of articles that have been published in the ReduSystems newsletters. It will give the reader technical information about light, user reviews and plant processes.

If you have any questions or would like to have more information or personal advice, please contact us.

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ReduWizard

Selecting the right coating: the ReduWizard tool can help you!

Selecting the right coating and dosage is important to get the best result. The ReduWizard makes it easy for you. Within seconds, you have an insight into the most suitable product. It also provides advice for the best dosage and timing for applying and removing the coating.

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