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We are living in interesting times. This is an understatement as far as cultivation in greenhouses is concerned. We will outline three developments that after 10,000 years of land cultivation 'on the plains of the earth' could completely change the face of crop growing.

We start with seeing new forms of indoor farming and layers, the first development. Dickson Despommier, Professor at Columbia University, developed the first concept of vertical farming in 1999. This quickly went from rooftop gardens to complete flats with cultivation floors. In commercial Horticulture we also have experience with this.

But as far as developments are concerned there is more going on. Energy-wise the current greenhouses are outdated. Incidence of light cannot be regulated, a lot of costly moisture and CO₂ escapes when windows are opened. Sudden bright sunlight can destroy a carefully created climate all at once. The many stands holding the greenhouse roofs are in the way of camera-operated cultivation. Plant Production Units remedy all these limitations in one go.

The second development is the availability of special LED lighting. With LED lighting we only provide wavelengths that are useful for growth and development of the crop. In contrary to the sun, traditional assimilation lighting and TL lighting, LED only omits one colour of light. No energy is wasted with light spectra that are not used or less used by the plant. This means we can provide exactly the colours that the plant needs for photosynthesis. Plants mainly need blue and red light for photosynthesis and far-red, a colour not even visible to the human eye but visible to the plant. The relationships between the light colours determine the form of the plant. The costs-of-ownership of LED lamps are decreasing steadily. See Haitz's Law.

The application of mathematical models for plant cultivation forms the third development. Our growth models are the result of years of research into the cultivation of cut flowers, pot plants, vegetables and fruit. We have processed crop measurements from hundreds of measuring fields at home and abroad since 1994. This includes the registration of fresh weight, dry matter, amount of harvested produce and development speed. We have distilled hard patterns from the countless measuring data that forms the basis for growth models. Depending on the ultimate objective we combine these growth models with economic calculation models. This means countless operational, tactical and strategic options and scenarios can be calculated. We calculate what is possible and what is not and obtain insight into causes and consequences.

Integration

The fourth development and real breakthrough as far as we are concerned is in the amalgamation of these developments supplemented by new technologies in the field of climate control, sensors, vision technology and automation. This creates a joint value that is so much more than the sum of the parts. In a few years new types of nurseries will be built all over the world where products can be cultivated in several layers using LED lighting and fully conditioned areas without daylight. **These multi-layered nurseries (these are now in Holland)** will be close to the consumers and provide many advantages such as a higher production level with a precisely predictable harvesting time and a controllable product as far as appearance, taste and nutritional value is concerned.

Unique in the world

For producers of vegetables, flowers and pot plants we scale up to Plant Production Units. Large-scale production areas distinguish themselves by the following features:

- Higher production
- Local for local production (grow where used)
- Customized production (quantity)
- Customized quality (taste, composition, appearance, etc)
- Higher space efficiency
- Higher energy efficiency
- Higher CO₂ efficiency
- No light contamination
- Low pesticide use
- Production possible everywhere
- Sustainable production

In order to make plant production possible all over the world you need to create ideal growing conditions with the Plant Production Units. These Plant Production Units vary in size and consist of several cultivation layers on top of each other. The surface of 1 hectare cultivation area can consist of 10 modules of 1000 m² which are stacked on top of each other. The ultimate dimensions are determined based on cultivation wishes, climate wishes, investment costs, production expectations, internal transport, automation and suchlike. The size of Plant Production Units can vary from rather small (less than 100 m² of growing area) to really big (up to 10.000 m² and even much more!)

In our Plant Production Units you determine the climate, at any time of the day. Whether it is summer or winter, day or night. This means you optimize the potential of your crop. In the Plant Production Units, the following options are separately controllable: **light colour, light intensity, light colour ratios, day length, infrared, light temperature, root temperature, plant temperature, irrigation, nutrition, air velocity, air composition, humidity and CO₂.**

You only provide the plant with what it needs at that time without wasting water, energy and raw materials. In principle production units can be placed anywhere: in or underneath a building, on a ship, at the North Pole, in the desert. We can now know exactly what climate the plant needs and then build. This means you invest only in what the plant needs. Customers wanting to invest in Plant Production Units go through an extensive research process with where cultivation wishes, climate wishes, investment costs, production expectations, internal transport and automation wishes are taken stock of. We establish the most suitable production model based and on the wishes of the plant and the customer captured in our Growing Recipes.

All this is done with the help of **Leading Horticultural companies that are experts** in their chosen fields and brought together to create one growing unit.

This is in many aspects an integrated measuring, planning, dosing and implementing system for the growth of a crop. Our approach is unique in the world. It has many angles and cannot be explained in two sentences. We invite you to explore our total approach on this site the way you want to.

- Measuring is the detailed establishment of the true needs of a certain plant.
- Planning entails making a route plan for growing. Laid down for each plant in a Plant-ID
- Dosing and balancing the right amount of light, etc. With the objective of allowing 'just-in-time assimilation' to arise and hence making precisely the desired product.
- Implementing the most recent scientific knowledge in daily practice. The right plant at the right time.

The term Master refers to various forms of mastery:

- getting a grip on growth and quality through research
- the customer, who pulls the strings more than ever; we make this possible
- the plant indicating what it wants; we do not provide averages, we do not allow torrents of light and moisture; the environment is strictly controlled
- a master also understands the place in the greater whole: the social role and relevance of the total system

The integrated character of the system not only has to do with considering growth variables in their context but also integration of disciplines to achieve this as well as our offer to customers of basic research up to Research Units and large-scale turnkey Plant Production Units.

In brief

Not a ray of sunlight will enter the greenhouse of the future if it is up to us. Sunlight will become LED light plus Infra Red. Plants will be given made-to-measure light, climate and nutrition. We will make the entire cultivation process more manageable and hence more profitable. This is a unique concept in the world.

We think it is the next logical step in the development of horticulture. A century ago crops went into a more protected environment in the greenhouse. Now protection is being increased using technology. In this closed off environment plants can develop better and the growth process can be managed better in a direction determined beforehand.

Production is increasingly going from 'quality per square centimetre' to 'quality per cubic centimetre'. Growing crops will be intense. At the same time more and more flexibility will be demanded. This requires full use of the crop's potential; what the plant has by nature. Our daily work mainly consists of discovering the possibilities of crops. We are looking for the optimum mix: can it be bigger, tastier, cheaper, prettier, faster, less perishable and more predictable? What nutritional value and harvesting periods does the client want at what time and where? In brief: can it be done differently? Can it be better? Can it be more sustainable? Can it be more profitable?

Previously research in this area took five or six years, now we are talking about months.

Our system provides countless advantages: constant quality, no wasting of water and energy and because it can take place in several layers it also saves space. And we can now produce where we want irrespective of climatic conditions. That makes a great difference in transport of products around the world.

Precise climate control, custom-designed By Horticultural Experts

In order to better use the potential of crops we design and build production rooms where the climate can be precisely controlled according to the wishes of the plant, the market and the customer.

We develop and deliver multilayer Plant Production Units, Research Units.

These climate rooms are fitted with one or more cultivation layers, varying in size from 1 m³ to thousands of cubic metres and are suitable for both research and production purposes.

Each plant is then given its so-called Plant-ID.

We also supervise up scaling to multilayer Production Units where “custom-designed climate” can be produced.

Using the newest LED technology it is now possible to adjust the light composition and light intensity exactly to the needs of the crop. Room temperature, root temperature, air humidity, CO₂, light intensity, light colour, air velocity, irrigation and nutritional value can all be separately and most accurately regulated. This is possible in several cultivation layers on top of one another.

Plant balance takes a central place

We can now actually look at the plant literally as a pair of scales. On one side of the scales we calculate with the aid of the growth factors (light, CO₂, water, nutrition and leaf area) how many grams of ‘sugar’ the plant can make. On the other side of the scales we calculate using the control factors (plant mass, sinks, temperature) how the plant can distribute these grams. By doing so we have made complex plant physiological knowledge practically applicable. Just as with an old fashioned pair of scales imbalance can be remedied in several ways: You can make the heavier weight lighter or the lighter weight heavier, Or a combination of both.

The Dutch Lead the way

We are entering an era when we have to look at more and more systems as a whole. Where everything is related to everything and we cannot progress by taking one variable separately. There are dozens of variables in plant growth. We have to look and decide "systematically". It is more about the relations and the balance than the parts.

Plant balance

If you harvest a tasteless strawberry in the winter then that is because there is not enough energy available for the strawberry. The crop does not produce enough sugars meaning that an imbalance arises. We can remedy this imbalance by making more sugar; for example adding more light or more leaf. We can also correct the imbalance by reducing the demand for sugars; by reducing the number of strawberries or by maintaining a lower development speed or by a combination of these measures. By looking for a solution from the idea of balance we already see that there are several options. With our modern world we calculate which solution leads to the highest yield.

The source of the models

Already back in 1994 we started carrying out crop measurements on a large scale. First in rose cultivation, later for countless other cut flowers, pot plants, vegetable and fruit crops. Hence both glasshouse and indoor crops. It actually does not matter whether you can influence the 'energy makers' or not. The plant principles are applicable everywhere with the right conversion even though that may sound strange. Growers have taken crop measurements for us all over the world at hundreds of measuring fields. For years they recorded exactly how many items they harvested, how much the fresh weight was, how much the dry matter percentage was and how fast the development speed was. We were able to distil patterns from these millions of measuring data. Nature appears to lay itself down with great accuracy. We discovered the relationship between daylight and dry matter production. And the relationship between the various assimilation lighting levels and dry matter production. And the relationship between CO₂ and dry matter production. And we calculated the exact relationship between temperature and development speed and we discovered that the development speed of the crop is simply and only managed by the temperature

Controlling production and quality

Prior to cultivation we determine on what day we want to harvest, what the end product is going to look like, how it should taste, etc. Then we calculate when the cultivation should start and what settings we need to realise this. Once the cultivation formula has been developed it can be repeated all over the world, time after time and always with the same result.

Process management

The climate in Plant Production Units is no longer affected by sunlight, outside climate, day/night rhythms, weather or seasonal influences. This provides unique opportunities to control production, quality and harvesting time according to tight planning. Ideal for exact management of tissue cultivation, transition from vitro to vivo, plant growing, propagation, nursery cultivation and production of countless crops!

We can now gear the cultivation of crops, for example towards medicinal purposes and functional food.

We adjust the offer directly to the demand and can coordinate with promotions at retail level for example.

In traditional greenhouse cultivation it is practically impossible to meet tight deadlines. Sudden climatic changes often lead to undesired delays or acceleration meaning that the connection to the demand is lost. In Plant Production Units we control cultivation completely and can deliver the agreed quality at exactly the agreed time.

Plant-ID

To prepare cultivation in multilayer Plant Production Units we develop a specific profile for each crop: the Plant-ID. This profile provides the plant specific ideal formula to manage a plant under completely controllable factors year-round, 24 hours per day based on the specifications determined beforehand.

This means the exact conversion is made to the required technology. Based on the information from the Plant-ID we determine what the ideal cultivation building and formula looks like.

In a current R&D facility in Den Bosch they can subject a plant simultaneously to 56 environment combinations. This makes it possible to obtain the desired Plant-ID in a very short period of time.

The Plant-ID forms the basis for the specifications to build a Plant Production Unit and the cultivation formula to be followed.

Total approach

We provide an integrated approach on several aspects or: ***total approach to crop growing working with leading Horticultural Company's After all:***

- we integrate on a larger scale than ever computer technology, light and photosynthesis know-how, economic know-how and measurement and control engineering.
- we offer our customers the entire spectrum of basic research into plant needs up to turnkey projects, implementation, technical after sales support, cultivation guidance, training and courses.
- we integrate dozens of variables which until now were studied separately and we look for the optimum mix for a certain plant ("Plant-ID").
- we look at the entire growth process "systematically". We see the interaction of the plant with its environment as an inseparable whole.
- we look at our work from several levels at the same time. At the research and production level we see the plant as customer (what does it need exactly at what time)

What are the results?

We have already seen many potential savings and values pass by in this introduction. Here are some of the most important again. With LED lighting we are using a sustainable form of lighting. By cultivating in layers we are saving a lot of space. It is technically possible to cultivate in five, ten or even twenty layers in a large hall. In a Plant Production Unit less evaporation is needed to cool the crop and all the water that the plant evaporates is collected and reused. This means we save 90% compared to traditional cultivation methods in greenhouses and open fields. For tomato cultivation in a greenhouse for example 1 cubic metre of water is needed per 70 kg of tomatoes. This is even 5 to 10 times as much for a kilogram of roses and pot plants. This sophisticated cultivation method will moreover provide mainly healthy plants, which makes a difference in the use of pesticides. Cultivation can also be speeded up. Halving the cultivation time is feasible and effective economically. We can guarantee the concentration of healthy components. We can provide identical crop performances anywhere in the world, even on industrial premises, or even in the desert. Production is possible anywhere where needed and where electricity can be created or supplied. ***We are going to grow local for local. This will save huge amounts on transport costs from producer to consumer.***

Grow popular food where ever

Or as a lot of people are trying to do today, you are looking for a nursery in the centre of a city and produce 'right around the corner where the consumer lives'; Urban Horticulture or Vertical Farming. Whatever your situation and goals might be, we have to take a very close look at it in order to create the Plant Paradise that you are looking for, including the Growing Recipes for the crops you want to grow. Again working with leading Horticultural companies we can create a Plant Production Unit as small as a 'walk-in-closet', or with a growing area of only 50 to a few hundred m². Or as big as a multi storey building, containing multi layer Plant Production Units, able to produce enough fresh vegetables to feed hundred thousands of people with hardly using any water!