Recent surveys show that “hand watering” continues to be the dominant method of irrigation in a number of small and medium-sized greenhouse operations around the world. At the same time, the greenhouse area has increased by about 35% during the past decade, reaching today about 1 million hectares in the world—of which 0.4 million in China and close to 0.2 million hectares in the Mediterranean area. In this increasingly competitive business of protected crops production, one expects each plant to survive! Irrigation is one of the most important horticultural practices in greenhouse production. If not optimal, the produce may even not be marketable. Moreover, an efficient greenhouse irrigation system can be fairly simple to install. Time for trading the greenhouse labour for an automated irrigation system? Prof. Heiner Lieth/UC Davis/California has the story.

One of the most important goals of greenhouse crop production is “uniformity”. This is particularly true for ornamental crops that must be marketed for particular target dates. At the same time the grower typically want plants to grow and develop at a fast rate. To assure this, he needs to make sure that the plants are never stressed. While some would argue that a little bit of stress could be used as a tool to “tone” plants or achieve some particular effect, plant stress always has negative effects.
production of the crop. Various types of systems are found in the greenhouse. These range from hydroponics systems where water is applied many times each day, to in-ground production systems which are watered a few times per week. In-ground production uses the soils buffering capacity to smooth out any errors in irrigation and fertilization. However, it does not allow for as much control as soil-less production systems. Virtually all greenhouse vegetable production is in artificial substrates. Also, during the past decades many cut-flower rose growers have converted from in-ground production to hydroponics' production (e.g. rock wool, coir, etc).

HAND-WATERING IS THE MOST EXPENSIVE APPROACH...
Most greenhouse operations have found that irrigating by hand is the most expensive approach. Invariable if growers find themselves under financial pressure, one of the first places to save money is by installing an automated irrigation system. Once they have done this, they never go back.

Allowing plants to show visible signs of wilting means that they are seriously stressed; in fact, plants show reduced growth rates even before signs of wilting become apparent. Many plants can also adapt to stressful conditions so that they may not show wilting even under very dry conditions where they have completely stopped growing.

PROVIDING WATER OF COURSE, BUT ALSO NUTRIENTS AND OXYGEN TO THE ROOTS
When it comes to a greenhouse operation, the purpose of irrigation is to provide water, nutrients, and oxygen to the roots of the plant. The root zone acts as both a reservoir and as a conduit for these. Before any decisions can be made regarding irrigation, it is important that the root zone medium be designed to optimise the
Frequently the question arises: "Which type of irrigation is best for which crops?" Generally, there is no definite best production system for a given crop. The issue usually boils down to cost and return-on-investment. For example cut-flower roses can theoretically be produced in any of the available production systems (in-ground, buckets, ... etc) with irrigation systems ranging from drip tape to overhead sprinkler irrigation.

A number of automated irrigation systems are available depending whether for in-ground crops, propagation crops, container-grown plants such as bedding plants, bench pots, hanging baskets, and nursery crops, as well as hydroponic production systems for vegetables and cut-flowers (rock wool, gravel-culture, fleece, coir, etc). They include overhead sprinklers and mist systems, surface irrigation (spot-sprayers and drip systems), and sub-surface systems (toughs, capillary mats, ebb and flood benches, and flooded floors). In theory, any of these systems could be used with any crop. In practice the issue is economic feasibility. For example, growing carnations into a hydroponic system would work, but the relatively low wholesale price of carnations might not be adequate to pay for the system; if one does have a market where the return would be higher, then such a system might make economic sense. Basically growers need to calculate the cost and then install a system that does the best job.

There are only a few situations where irrigation by hand is feasible. If the crop needs to be inspected plant-by-plant, then this is an ideal way to do so. Also, there may be reasons to do some touch-up if the greenhouse environment is not uniform, so that some plants dry out much faster than others.

**While automated irrigation is the most cost effective option**

Automated irrigation is the most cost effective way to irrigate. It also allows for more uniform irrigation than can be achieved by hand. Many growers feel that they can manually irrigate to perfection. However, there is no way that a grower can precisely administer the exact amount of water that is needed by each plant. It is much more likely that this can be accomplished by an automated system if the proper design criteria are applied.

The entire irrigation system consists of several circuits, each controlled by an irrigation valve. The water generally starts at some source (either municipal water or a pumping station), which puts the water under pressure. It then passes through a facility where dissolved fertilizer is injected into the water. The resulting irrigation solution is then distributed throughout the nursery with large-diameter supply pipes. This brings irrigation solution to the starting point of each irrigation circuit. When the valve in the circuit is opened, the water flows and brings the circuit up to pressure. Irrigation solution then emits from the emitters that are attached to the circuit.

The important aspect to
designing the system properly is to control the pressure at each emitter. This is quite difficult to do since the pressure drops as the distance from the pump increases. Even within an irrigation circuit, the pressure is always higher near the valve than further along the circuit. To achieve the greatest possible uniformity requires that pressure regulator be installed at various places in the system. It is generally a good idea to at least have one at each valve. It is also a good idea to use pressure regulation at each emitter. Pressure compensating emitters are also available.

Whenever small emitters are used one should also use filters throughout the irrigation system. If an error is made in the fertilizer mixing, resulting in precipitates forming in the pipes, or if the source water is not completely
clean, then particles can become lodged in the emitters, rendering them useless. Filters basically intercept any particles and thus protect emitters from clogging.

THE CONTROL SYSTEM: FROM THE 'LOOK AND FEEL’ APPROACH TO SENSOR-BASED

The process of making a decision on when to irrigate and how much is never easy. Traditionally growers have used media that can be over-irrigated without any penalty. However, with increased environmental awareness many growers must find ways to reduce the water that is discarded. Also, with tighter profit margins they are continually searching for ways to become more efficient.

Many growers use a “look and feel” approach to irrigating. They basically inspect the plants once or twice a day to see if they need water. As mentioned above, the plants can adapt so that they will not show signs of wilting unless the situation is already critical. Using ones’ fingers to determine if there is adequate water in the substrate may work sometimes, but we have found that even relatively dry conditions, where not much available water is present, can still feel moist to the touch. Thus the “look and feel” method, although better than guesswork, is not the best way and is certain to result in stressful conditions for the plant at least sometimes.

Programmable timers are very common in the industry. Using these allows growers to assure that a minimum irrigation schedule is maintained. Many growers irrigate on a fixed schedule and for a fixed duration at each irrigation. In conjunction with well-drained media, this method is very effective, but can result in substantial waste, particularly if the grower does not make seasonal adjustments.

Some methods have been developed that can be used to estimate how much water the crop has used. Such methods use a combination of environmental variables (light, air temperature, relative humidity or vapour pressure deficit, and/or wind speed) to calculate the amount of accumulated water use of the crop. Many of the greenhouse computer control systems on the market have such methods available. It should be noted that these methods use mathematical models to estimate cumulative water use. These calculations are somewhat prone to errors and should only be used as guidelines. Growers should always monitor whether the timing of irrigations is happening at the frequency that is ideal for crop growth.

Sensor-based irrigation is the best approach for assuring that the plants get what they need. A sensor is used to determine how full the reservoir (root zone) is. When the root zone becomes depleted, the sensor signals this to the controller and it can then control the irrigation accordingly. The tricky part is that on hot dry days, all circuits may need irrigation at the same time. In such situations, the controller must be able to prioritise irrigations. In fact, it may be necessary for the grower to override the controller so as to give each circuit a turn at providing water during the day. In nurseries that have inadequate capacity, it is not uncommon that everything must be watered on a rotation regardless of need, because otherwise there would be no way to keep all the plants alive during the afternoon.

BETTER USE TENSIOMETERS RATHER THAN SENSORS BASED ON ELECTRICAL PROPERTIES

Not all moisture sensors are the same. There is tremendous variation in costs and level of sophistication. Sensors based on electrical properties typically are affected by the level of fertilizer in the irrigation solution and are thus not ideal. One sensor that is immune to salts is the tensiometer. It has been around for many years and is available for various applications. However, the tensiometers that are designed for field soils should not be used with crops growing in artificial substrates. The field tensiometer typically has a light, low-flow ceramic tip with a gauge that reads from 0 to 100 kPa; in substrates used with potted plants or hydroponics systems, the ceramic needs to be a high-flow (more coarse) ceramic with a tension gauge that allows
one to read off the difference between 1 and 5 kPa.

When using a tensiometer, the manufacturer’s instructions to set it up (it has to be filled with water, etc) have to be precisely followed. During installation, a location has to be selected that will be representative for how the grower wishes to irrigate the crop. The ceramic tip should be inserted into the substrate where the roots are located. The gauge should be clearly visible. After installation, the crop should be irrigated thoroughly, being sure to saturate the medium surrounding the tensiometer. After all excess water has dripped from the root zone, the reading on the tensiometer must be checked. This is the baseline reading (the “zero-point”). This reading is never zero because the water in the tensiometer will always add some tension to the gauge. Adding 1.0 kPa and 5 kPa to this number will determine the low-tension set-point and the high-tension set-point. The irrigation must start when the high-tension set-point is reached. Then during the irrigation the tension will drop. If water is applied slowly, then one can turn the irrigation system off after the low-tension set-point is passed.

Pressure transducers can be added to tensiometers to allow them to be integrated into computerized irrigation systems. This allows for combining tensiometer with timers and prioritised queuing to achieve the greatest possible level of irrigation optimisation.

While there is always room for further innovation, growers have access to a wide range of systems, each with its particular intricacies in installation. Growers should always be careful to create irrigation systems that are uniform; they should also frequently check this uniformity. Distributors should be careful to assure that the growers have accurate information about the irrigation products. They should also provide growers with the latest information on how to design uniform systems using these products. Both growers and distributors should work to get as much reliable information as possible.