Watering regime is a strong tool to control plant growth, plant balance, production and quality (including, e.g. blossom-end rot).

(Some images have been repeated from previous articles to demonstrate the author's point.)

Controlling Plant Balance by Irrigation

Plants that are out of balance, either too vegetative or too generative, produce less than well-balanced plants. Possible tools for plant balance control include climate control, irrigation regime and plant management. By ELLY NEDERHOFF and BERT HOUTER

Tomato plant in vegetative state of balance. Typical are strong head, thick stem at the top and lush leaf growth. Fruit production will be poor.

Tomato plant in a generative state. The plant head is meagre, as most energy goes towards fruit production (not visible).

Left: *Hot dry summer conditions and sharp sunlight have a generative effect. Plants need plenty of water with a low EC (CF).*
Right: *Mellower conditions stimulate vegetative growth, but light loss costs production.*

Plant balance

In greenhouse crops like tomatoes, capsicums and cucumbers, it is essential to maintain a good plant balance in order to achieve optimal production over the whole growing season. Plant balance is, in simple words, the balance between leaves and fruit in a plant. The term is mostly used for fruit-producing crops, but the principle also applies to flowering ornamental crops. Plants that are unbalanced are either 'vegetative' or 'generative'. Vegetative plants are in a state that most of their energy goes towards leaf growth, and very little towards fruit production. The opposite, generative plants, means that plants put most energy in fruit growth, and have little left to invest in new leaves and in the growing point (the plant head). A strong plant head is essential for continuation of the production. Also a healthy root system is vital. Unbalanced plants always underperform. Vegetative plants underperform because they don't carry enough fruit to achieve a high production. Generative plants underperform because they have insufficient leaf area to manufacture enough sugars to fill the growing fruit.

How to recognise generative or vegetative plants

Vegetative plants typically have large leaves, thick stems, strong head, and generally slow fruit development. In contrast, generative plants have small leaves, a thin stem, weak head, small intense flowers, and possibly a large fruit load. Fruit load is an indicator, but can be misleading. After all, a lot of mature fruit on the plant tell that fruit set was good some time ago, but doesn't say anything about the present. The best indicator of plant balance is the plant head. A weak head and a stem that is thin at the top indicates the plant is working on its fruit, thus is generative. A thick, full plant head is typical for a vegetative plant. Plant balance can best be assessed by accurate observations, best done by using a crop-recording or crop-registration system. This will show trends in an early stage so that corrective measures can be taken in time.

Seasons, stages, greenhouse, growing medium

In general, mild conditions stimulate lush growth, resulting in vegetative plants. In contrast, harsh conditions and stress makes plants generative. This is because plants attempt to survive any adverse conditions by producing more seeds.

Plant balance is partly a seasonal effect. Mild spring weather with high humidity and good light stimulates plant vigour, so makes plants vegetative. In contrast, summer conditions with high radiation, high plant temperature and low humidity put stress on the plants and makes them generative.

The type of greenhouse plays a role too. In a double-poly greenhouse the conditions are mellower (slightly higher humidity and more diffuse light) than in a glasshouse. The milder growing conditions of a plastic greenhouse stimulate vegetative growth, while a glasshouse stimulates generative development.

There are many more powerful effects: variety (some varieties are naturally more vegetative, others more generative); grafting (grafted plants are more vegetative); and root-zone conditions.

It is possible that many factors work in one direction. For instance, a young grafted tomato crop in spring in peat in a plastic greenhouse will naturally become very vegetative. The grower has to force it into flowering and fruit set by strong generative actions, or otherwise the production will be very disappointing.

Tools

When the conditions push the plant balance in one direction, it is up to the grower to restore the balance by steering into the opposite direction. In the previous issue *(Jan/Feb 2009)* we introduced the tools that are available in a greenhouse for plant balance control: temperature, humidity and other climatic factors, irrigation, as well plant management. Effects of temperature were discussed in detail in a separate article in the same issue. In this issue another article discusses how plant management actions can be used for plant balance control. The present article discusses effects of irrigation.

Water content of the slab

Irrigation has a strong effect on the root-zone conditions. But it starts with the growing medium. Substrates with good water-holding capacity (e.g. peat, coco coir, sawdust) are on average rather wet. This creates lush growth, so the plant becomes vegetative. In contrast, growing media with a limited water-holding capacity (pumice, sand) are on average drier, and have a generative effect on plants.

Irrigation can be used as a tool for plant balance control, because it affects the water content (wetness) and the EC of the growing medium. Both determine whether the growing conditions are either mild or harsh, which determines whether plants become vegetative or generative. A high water content in the root-zone creates easy growing conditions, which stimulates lush vegetative growth. Low water content in the root-zone, or in other words a dry slab, creates harsh growing conditions, which makes plants generative. This is one way how the irrigation regime affects plant balance.

Each growing medium has special requirements towards watering regime, to suit its water holding capacity.

Sawdust used as a growing medium for capsicum (pepper). High water holding capacity can lead to too wet substrate and would steer the plants vegetatively.

Pumice has a low water holding capacity. If it gets too dry, plants get stressed and become too generative.

Capsicum on cococoir. Growing medium and watering regime can influence everything.

EC or CF

The second way that irrigation affects plant balance is through conductivity, also known as EC (Electric Conductivity) or CF (Conductivity Factor, which is 10 x EC). This is basically the strength of the nutrient solution. EC of the slab determines how easy water is taken up. Pure water or nutrient solution with a very low EC is easily taken up by plants. Hence low EC causes lush vegetative growth. In contrast, nutrient solution with a high EC, or salty water, is hard to take up. High EC hampers water uptake and is tough on the plants, which causes generative development.

Be aware that EC has many effects on quantity and quality of the produce. The main concern is that the plants get sufficient water and nutrients. Under high radiation, plants need huge amounts of water to replenish the loss by transpiration. Then the EC must be low, because a solution with low EC is much easier for plants to take up. But at the same time, plants in summer need a lot of nutrients. The low concentration of nutrients in the solution is compensated for by the large volume that is taken up. Under low radiation, the opposite occurs: then the EC must be increased to ensure plants get sufficient nutrients.

Irrigation regime

Generally, plants thrive in a reasonably stable root-zone environment, and suffer from unwanted fluctuations in EC and water content. Intentional variations can be applied to influence how the plants grow. Irrigation can therefore be used to steer plant balance. The principle is that high water content and low EC both stimulate vegetative growth, whereas low water content and a high EC stimulate generative development.

Certain water content and EC levels in the root-zone can be achieved in many ways, namely by variations in the timing, variations in dose and frequency of irrigation, variations in drain volume, as well as variations in overnight dry back (water loss from the growing medium). Obviously, it is always paramount that plants receive their daily amount of nutrient solution.

Watering regime can control plant balance through start & stop time, volume & frequency, drain control, overnight dry-back, EC and more.

Required supply and drain

The amount of nutrient solution needed on one day can be calculated from the conditions. The absolute minimum supply is just as much as the plants take up for transpiration (the largest part), plus the amount needed for growth and filling up fruit (a much smaller part). Transpiration depends largely on radiation and partly on humidity and other factors. However, it is necessary to give more water than strictly needed. This is to overcome the unevenness between drippers, and to ensure that even the largest plants get sufficient water. Oversupply is also needed to 'flush' the growing medium, and to ensure good water supply to every little corner of the mat or slab. Therefore, the daily supply must be much higher than absolute minimum, for instance, by 30%. This will then lead to the same percentage drain (e.g. 30%). Obviously, more drain means more supply, so higher expenses for water and fertilisers, and more waste water or more recycled water to treat.

Dose and frequency of irrigation cycles

If a certain amount of water is required on a day, the grower can choose to give it either in many small irrigation cycles or in a few large cycles spread over the day (or anything in between). The amount of water per cycle affects the water content and EC in the growing medium as well as the drain percentage. This can be understood by looking at what happens in the morning, when the slab is dry and the first irrigation cycle starts. If it is a small amount, it will be readily absorbed by the dry growing medium. The water will spread evenly through the slab or bag, and only a minimal amount will drain out.

In contrast, if the first cycle dumps a very large amount of water on the dry growing medium, this large amount will not be absorbed, but will largely drain out. The slab will not get very wet from this irrigation cycle. If then the second cycle would come a lot later, and would again be a large amount of water on a dry growing medium, the same thing

These plants are stressed as they are more exposed than the others. Make sure the drain measurement is representative for the whole crop.

would happen again. Hence, large irrigation cycles with quite some time in between will result in more drain, a drier growing medium and also a higher EC. Both a dry growing medium and a high EC have a generative effect on the plants, as discussed earlier. Many small irrigation cycles create wetter slabs with lower EC, which have a vegetative effect on the plants.

Start and stop time

The start and stop time of irrigation indicate the times of the first and last irrigation cycle in the day. Both affect plant growth. An earlier start in the morning or a later stop in the afternoon will lead to a wetter root-zone at night and therefore have a vegetative effect. In contrast, a late start in the morning and an early stop in the afternoon results in a drier root-zone at night, which has a generative effect on plants. The start and stop times are used to control the amount of dry back overnight *(see below)*.

Table 1.

How irrigation regime can be used as tool for plant balance control.

Irrigation variable	Steering in vegetative direction	Steering in generative direction
Water content	Higher (wetter substrate)	Lower (dryer substrate)
EC in substrate	Low	High
Volume of cycle	Small cycles (but many) → wetter substrate	Larger cycles (but fewer) → dryer substrate
Frequency of cycles	More cycles per day (although small) → wetter substrate	Fewer cycles per day (although larger) → dryer substrate
Start time in morning	Earlier start → wetter	Later start → dryer
Stop time at night	Later stop → wetter	Earlier stop → dryer
Water loss overnight	Low (wetter substrate)	Higher (dryer substrate)

It is important that the crop is transpiring ('is active') when irrigation is supplied. Irrigation while there is no transpiration (for instance very early or very late in the day), will result in a too wet root-zone and possibly lead to root problems. Sometimes root pressure forces water into the crop, causing both plant and fruit damage. A popular recommendation is: 'transpiration before irrigation'.

Steering by drain

The drain percentage is used as a steering tool. It also works through its influence on the wetness and the EC of the growing medium. There are various aspects. Excessive drain can be due to excessive watering, or due to incomplete absorption of a large volume on a dry growing medium (as described earlier). Ample drain caused by ample water supply will lead to a wet growing medium and low EC. Both stimulate water uptake and thus have a vegetative effect on plants. Limited supply does the opposite. However, this is just in a nutshell. In fact, a lot can be done by controlling the drain percentage and the timing of the first and last drain, but this requires a good water content meter.

Always monitor watering and drain. They are important for everything including plant balance control.

Tomatoes in a steady state of production.

Overnight dry back

The need for watering at night depends on the water-holding capacity of the growing medium, and also on the weather, the crop and other conditions. On top of that, it depends on how the grower wants to steer the crop. A growing medium with good water-holding capacity generally does not need any watering at night. It is normal that the growing medium dries back during the night, so that it has its lowest water content early in the morning. The amount of dry back is the amount of water loss expressed as a percentage. The dry back has an effect on the plant balance. More dry back results in a lower water content early in the morning, which has a generative effect. Less dry back results in higher water content at night and early in the morning, which has a vegetative effect.

Water content meter

A comprehensive system was developed by the company Grodan based on the use of Grodan rockwool growing medium and the water content meter for irrigation control. A key factor is that rockwool has a consistent quality, which allows refined control. The advanced water content meter accurately measures the wetness of the slab. The computer then applies irrigation very precisely to achieve the required water content, drain, dry back and EC. This in turn steers plant growth and also the vegetative/generative balance. In theory, the water content meter can also be applied in other media such as coco coir and peat. However, the outcome is inaccurate if the growing media does not have a consistent quality.

Other aspects

It is important to be aware of the many other effects of irrigation as well. For instance, irrigation with too low EC can cause unwanted swelling and hence fruit cracking. Irrigation regime influences growth, production, fruit quality, deficiencies and physiological disorders.

For maximum performance, the total volume of the growing medium should be available to the roots. Some growing media, such as peat, are sensitive to drying out. If irreversible dry-out of parts of the slab occurs, the root-zone volume is effectively reduced. When plants have a heavy fruit load, there is a real risk of root death. Be aware of all subtle details and avoid sudden changes in the root-zone.

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