MODULE 3

MANAGING PLANT NEEDS FROM THE BEGINNING TO THE END OF THE CROP.

This section reviews the following key practices that are required to successfully grow and manage a crop that delivers high yields and good quality:

01. **Good irrigation practices**
02. **Skilled and timely management of flowering and fruiting**
03. **Skilled and timely management of plant nutrition and fertilisers**
04. **Prevention, detection and control of pests and diseases**
05. **Detection and remediation of serious plant stress**
06. **Assessing crop performance yield or quality issues**

As we deal with each of these practices we will outline Phuong's knowledge, his practice and inputs and most importantly how he assesses the need for corrective action to ensure good plant health and production.

01. IRRIGATION

Good irrigation depends on having a reliable, even irrigation system and checking output. This requires good design, testing and maintenance to set up right and keep it operating as planned. Excess and deficiency of water are undesirable because of their negative effect on plants. Uneven watering within the crop means some plants are stressed by under or over watering and creates salinity hot spots. These will stress roots and create a much greater risk of root disease starting on weak plants and spreading to healthier ones. Avoiding such problems depends on understanding and controlling your systems output, and knowing your soil type and its refill capacity and water holding ability.

If you are using compost, improving soil structure and reducing salinity the root profile on your plants will deepen considerably and water will penetrate more evenly and will be held for longer in the soil due to the increased organic matter.

Good irrigation depends on having a reliable, even irrigation system and checking output.

IRRIGATION CONTINUED...

This means your irrigation practices will have to change because you are refilling a bigger root zone at greater depth - but do not keep watering just because the surface is dry – it may have plenty of water just below the surface. You may initially need more water before and at planting to wet up the soil once compost is added.

Phuong checks his soil around the root zone during and after watering to make sure he has provided enough water, but not too much. Excessive irrigation also adds to humidity in the greenhouse which can be promote root and foliar disease and encourages weeds. Now that Phuong can no longer go by surface moisture alone he regularly digs and checks around the roots to make sure they have enough moisture. To ensure reliable irrigation Phuong also regularly checks his drippers to make sure they are performing evenly and are not becoming blocked. If necessary, Phuong cleans or replaces his poly pipe.

For growers with very salty soils because of impervious layers, high water tables or high EC irrigation water it is necessary to change the irrigation program to give more frequent, but shorter pulses of water. This keeps pushing salt away from the root zone and avoids adding to any water table underneath. You will still be able to provide enough water for the plant roots and will not leach nutrients away. An occasional bigger leaching irrigation may also be needed to push salts further away. This strategy has given many Virginia capsicum growers with salt problems a major increase in production, often doubling their yield or more in the first season. Planting in raised beds can further assist in pushing salt away from root zones, but do not over water and flood the mounds.

RELEVANT VIDEO, FACT SHEETS & RESOURCES:

> Salinity Management (fact sheet)

02. MANAGING FLOWERING & SETTING

Phuong now regularly picks 20 or more first class capsicum fruit per plant over a 6-7 month harvest period from about 3 successful settings. The time from planting to first pick depends on the time of year. For example a July planting normally commences picking in about 16 weeks and a summer planting in about 12 weeks.

If we follow the typical Virginia planting time in May Phuong expects that in July there will be more fruit setting, but cold weather issues are likely to reduce fruit quality due to poor seed formation. Setting tends to be less in mid summer. The number of flower sets that form depends on planting time and a range of management factors including fruit load already on the plant and plant health which depends on root health, nutrients, watering and climate management and of course pests and diseases.

It is very important to avoid letting your plants become too vegetative and grow beautifully but not set enough fruit. A range of factors can influence whether a plant is more vegetative or more generative.

Phuong's tips on flowers & fruit set:

> Small flowers produce a stronger fruit than oversized flowers that are typical in cold weather

> If the flowers are hanging down then flowers set more easily. If the flower stem is straight up something may be wrong leading to weaker setting

> Fungicides tend to damage flowers

> Turn the first set of flowers outward to avoid trapping and distortion of expanding fruit. This makes picking easier & faster and ensures more good looking first grade fruit.

MANAGING FLOWERING & SETTING CONTINUED...

The main causes of overly vegetative plants are low light (caused by chalking too early, or by condensation on the roof), and too much nitrogen promoting rapid growth. This is further complicated because plant needs change as the plant develops and depend on the time of year. Water can be used to stretch slow plants when they are young provided it is not too cold or other problems are weakening the plant. Conversely drying the soil up a bit may help to slow down a young plant that is too vegetative and help to stimulate flowering.

During the first 1-2 settings in warm weather Phuong finds he usually needs to stretch the plant with water or the fruit will be too close together on the plant and they will become deformed as they expand. Generally while setting the plant needs plenty of water to ensure nutrient uptake and tissue expansion in the fruit.

RELEVANT VIDEO, FACT SHEETS & RESOURCES:

> Managing plant needs - nutrition (fact sheet)
> Greenhouse design and climate management (fact sheet)

03. PLANT NUTRITION

CHANGING NEEDS

Plant nutrient needs change over time and as weather conditions change. As plants grow and begin flowering and fruiting they require more of some nutrients (and less of others) to support plant needs. It is not good to apply nutrients unnecessarily, or deprive plants of what they need. Plants are always developing invisible new cells that will become new growth, flowers and fruit, so we cannot see any deficiency affecting them until it is too late. Nutrients are most effective when they are applied at the right time and at the right amount, and in an easy plant available form. Here we outline Phuong's general feeding program to give some idea when plants will be in need of key nutrients in his crops. Much more information is contained in **Module 1. 'Essential Knowledge'**, including changing plant needs, nutrient imbalances, and images of nutrient deficiencies and excesses. **Leaf testing is the only sure way to confirm your actual plant nutrient levels.**

Nutrients are most effective when they are applied at the right time and at the right amount, and in an easy plant available form.

PHUONG'S PROGRAM

After planting the next critical stage for plan nutrition should be at flowering and fruit set, especially ensuring adequate potassium for strong flowers that will set well. To make sure nothing is lacking a leaf test should be conducted just as flowering commences. When there are a couple of fruit sets check again how the fruit is developing. If the plant slows down then identify and provide anything that is deficient. **If the plant is going OK leave it alone!**

PHUONG'S PROGRAM CONTINUED...

Phuong uses the following nutrients according to identified plant needs:

> If potassium is low in the leaf test he provides a small dose, maybe two, through the dripper to help the blossom to last on the plant and increase the fruit set.

> If flowers still look weak then he does an additional foliar application (beware of adding potassium unnecessarily and locking out trace elements by creating an excess, or even damaging soil structure as with sodium)

> If boron is deficient a foliar allocation will be needed to enhance setting. Since Phuong has been using compost he has rarely needed to add boron because there is enhanced uptake from his stronger deeper roots, and the sodium is leaching out more easily with his improved soil structure which makes the boron more available.

> Sometimes plants may need additional nitrogen and phosphorous for sizing the fruit if there is a big setting with insufficient fertiliser in the soil. Be very careful about the quantity and timing as too much N and P will interfere with flowering and make the plant turn vegetative. If the plant has just begun setting Phuong finds that NPK can make the plant more vegetative causing the flowers to drop off (also Agrifos® because it contains P, or even leaching solutions that reduce salt around the roots).

> Phuong will also put calcium through the dripper just before hot weather when he has small fruit (plum size) to help avoid burning and make the leaf thicker and stronger.

BURNING OR BLOSSOM END ROT

A combination of factors lead to fruit burning or blossom end rot. Water stress and calcium deficiency are commonly involved and if chloride levels in the plant are excessive this can make plant tissues more sensitive to burning. The plum sized fruit is most susceptible to damage, especially if they turn dull rather than shiny. But any size fruit can burn and often does.

Phuong says that it is vital to add calcium if the weather is hot to prevent blossom end rot. If more than one day of hot weather is coming and you think your plants will need more calcium you must feed them the day before it gets hot as plants will not take up calcium during the heat of the day. Some research indicates that watering at night can assist extra calcium uptake in capsicums, but only calcium - not any other nutrients.

These days Phuong is seeing less blossom end rot and waits to see symptoms first before adding calcium, as he finds that his plants are accessing calcium in the soil more efficiently since he began using compost.

Tissue tests can tell you what the calcium and chloride levels are but results are likely to take too long to be of assistance if you are sending samples off just before an expected hot spell.

NOTE: During vey hot days too much ventilation can lower humidity and increase plant transpiration and soil evaporation until the plant is under severe water stress. These are very dangerous conditions for fruit burn. It is better to shut the house up and keep humidity high. The plants will shut down but will be less likely to become water stressed.

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COLD NIGHTS

Cold nights can be a trap for wasting fertiliser and damaging roots. Even though the plants may need feeding you cannot effectively do this as water and nutrients will be in excess for the chilled and inactive roots. Wait until the weather warms for a few days then feed. Always remember to not give too much water in cold weather. The way out of this is to use foliar applications of nutrients because you can spray nutrients on the leaf at any time of year, but this needs to be early in the morning. If you apply them too late in the day the plant shuts down and does not take it in. This may lead to burning of the leaf overnight and to disease issues because of wet leaves.

EXCESS NITROGEN

Excess nitrogen has it own damage symptoms, but may also add to pest and disease attack. Plants high in nitrates tend to be more vegetative and more attractive to pests because they are higher in sugars which boost pest activity and breeding, and they are also more vulnerable to attack by diseases. It is possible that what sometimes looks like pesticide failure may have something to do with plants that have become very attractive to pests and diseases. A plant with balanced nutrition is strong and less vulnerable to attack, **so make sure your plant is happy!**

FEEDING METHOD

At planting in winter time Phuong sometimes uses a little phosphorous to help the seedling roots. A couple of weeks after planting Phuong supplies NPK through the dripper and trace elements on the leaf as required, e.g in cold weather.

Phuong is always learning and recently noted from a workshop on changing plant needs that older plants may need molybdenum to keep them producing. He has no molybdenum (Mo) in the soil, but will now look into this given the role of Mo later in older plants.

RELEVANT VIDEO, FACT SHEETS & RESOURCES:

- Managing plant needs - nutrition (fact sheet)
- Nutrient deficiency and toxicity in capsicums (poster)
- Trace elements - stimulation and antagonism chart (fact sheet)
- Sending a leaf test for nutrient issues (fact sheet)

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04. PEST & DISEASE CONTROL

INTEGRATED PEST MANAGEMENT

Pesticide Program

As Phuong has developed an effective, regular monitoring program his spray applications have generally reduced because he sprays only when needed and checks results to decide if he needs to spray again. His chemical rotation program – now shared by two neighbours has also been more effective.

Reduced spraying has brought other benefits apart from time and $$ saved, including improvements in plant health and especially in the flowers. Fungicides seem to stress capsicum flowers significantly. At lower spray levels he found many new species of insects and animals in his crops including bees, lizards, dragonflys, and various beetles. Some of these were helpful and some were neither good nor bad. Just grateful the spraying had reduced!

Sometimes Phuong still finds he has to spray more than he would like for red spider mites especially. There is often a problem of resistant insects that can come from neighbouring properties with poorly managed old crops and spray programs.

Prevention & non-chemical strategies

Phuong does not simply rely on a good pesticide program to keep his pests in check. He routinely control weeds that host pests and strictly limits people and vehicles coming onto his property to the extent that he does his own cultivating, compost spreading and fumigating to reduce the risk of diseases being transferred onto his property.

Phuong has found that reducing his plant density has made it much easier to achieve good spray coverage which increases his ability to use other non-systemic and softer chemicals more effectively.

Phuong is now planting selected native vegetation outside his greenhouses to replace weeds and host beneficial insects that may contribute to pest control.

Phuong is ready to adopt a bio-control program now proven in 15 capsicum crops throughout Virginia as successful at controlling all key pests including Western flower thrips.

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RELEVANT VIDEO, FACT SHEETS & RESOURCES:

- Managing pests & diseases (fact sheet)
- Succesful biological control in a capsicum crop 1 (video)
- Succesful biological control in a capsicum crop 2 (video)
- Bio-control agents poster
- Contact details for biological control agent suppliers and consultants:

JAMES ALTMANN - Biological Services, 0427 846 977,
info@biologicalservices.com

LACHLAN CHILMAN - Manchil Services, 0403 727 252,
lachlanchilman@hotmail.com

PEST & DISEASE CONTROL CONTINUED...

> Revegetation by Design Guidebook

> Guide to using native plants on the Northern Adelaide Plains

05. PLANT STRESS

There are a range of conditions capable of stressing plants. They tend to be difficult to control in low-tech greenhouses. It is important to limit their occurrence, reduce their severity, or in the worst case scenarios know how to help your plant recover as quickly as possible from any set-backs.

LIGHT EFFECTS

If chalk is applied too early – ie when light and temperature is still too low – plants will 'stretch' (become more vegetative) as they reach for the light and will set much less fruit or none at all. This reduction in setting is a big issue in low glasshouses with a limit on plant height. The same effect is created by sustained cloudy, cool weather like the recent 2012 spring in Virginia, that caused many plants to become more vegetative in their early development with a resulting loss in fruit set and quality.

If planting in late winter wait till the first set before applying chalk unless it is very hot. If early chalking is needed, say in September or October make it light and add more later or the plant will begin to stretch and reduce its total fruit set. Once the plants are supporting fruit and become more generative chalk won't stretch them too much.

Stretching can also be caused by condensation on polysheet coverings that are not treated to reduce droplet formation. Water droplets reflect up to 30% to 50% of the useable light entering a greenhouse. This problem is greatly reduced by purchasing polysheet with inbuilt anti-condensation properties, or by using a spray-on anti-condensate. These technologies work by assisting droplets to merge and run down off the ceiling, resotring some of the light penetration.

OVER & UNDER WATERING

Overwatering can lead to root diseases and 'drowning', especially in cold weather and poorly drained soils. Under watering will lead to drought stress and nutrient uptake issues. These effects can become very severe if not managed. Probably the most stressful situation is going from one extreme to the other so checking and adjusting irrigation outputs needs to be done regularly - at least before each crop.

Water imbalance can be avoided by developing a good irrigation program and by checking water penetration just after irrigation to make sure it has filled the root zone (enough), but not saturated beyond this.

Irrigation management is complicated in areas with shallow soils that have drainage issues. In these cases watering should be more frequent but lighter to avoid over-wetting and drying out.

Water imbalance can be avoided by developing a good irrigation program and by checking water penetration just after irrigation to make sure it has filled the root zone (enough), but not saturated beyond this.

OVER & UNDER WATERING CONTINUED...

Phuong checks his watering about once a week which keeps him in touch with the impact of changing weather. He uses a range of means to check he is on track:

> Looking at the plant: Phuong checks for water deficiency early morning and late afternoon by the colour on the plant growing tip. In the morning this shows up as leaves looking too light in colour, but in the afternoon it shows as them being too dark. If the soil is too wet the plants are paler green all day.

> Checking the ground: Excess water is most easily checked by looking at the ground. He not only digs and looks at the soil and root zone, but also feels the soil in his hand to make sure it is wet enough and not too wet.

> Checking the roots: Another simple way of assessing if irrigation is adequate is to check that root strength is good – ie does it extend beyond the leaf margin.

CORRECTING WATER ISSUES

Witholding water is straightforward – turn off the tap until the soil has dried sufficiently and the plant roots can breathe again. In extreme cases if the plants are young you may want to ventilate the soil with a hand rotary/fork.

When the plants lack water just irrigate and let them recover, but not in the heat of the day as this can 'cook the roots' with warm water and low oxygen – a bad combination. It will also favour disease development. It is best to wait until conditions have cooled, even if this is much later in the day. Late watering and night watering can actually assist calcium uptake which is critical for reducing blossom end rot if it is not too cold for the roots to take it up. Be careful to give adequate water before hot weather sets in!

LOW TEMPERATURE EFFECTS

When it is too cold or too hot capsicum fruit does not set well. The fruits have less seeds and are generally poorer quality. This is because when the flower opens in cold weather even though the fruit will set OK, there are not enough hormones to form seeds. A lack of seed affects fruit development leading to thinner flesh, and the fruit is sometimes longer and more distorted.

Roots may become seriously weakened during cold weather so it is very important to not overwater or over-feed through the drippers in colder months. This is most likely to occur before flowering commences. From then on flowers activate the hormones that drive growth forward. Foliar applications (early in the day) can supply any required nutrients.

Cold conditions will also require ventilation if the greenhouse is too humid. If humidity is not an issue, don't worry, just keep the house as warm as possible with the sides down. You can even use a temporary plastic inner skin to keep plants warmer in winter, but watch out for humidity building up.

Roots may become seriously weakened during cold weather so it is very important to not overwater or over-feed through the drippers in colder months.

HEAT STRESS

Heat burning on hot sunny days is more of a problem for the capsicum fruit than the plant, except under the most severe heat conditions, so Phuong only uses chalk to reduce the risk of burning once there is fruit, to avoid stretching the plant. It is unusual to get a severe heat wave prior to this stage (fruit damage is more likely in warm to hot weather if there is a lack of water/inadequate calcium leading to blossom end rot.)

The early signs of heat stress include; flowers dropping, fruit not growing, maybe leaf burning if the plants are really stressed.

Excess heat may require both ventilation and watering, but do not water in the heat – only early or late in the day. So watch the weather and do not get caught out when the plants may be needing extra water. There is not much else that can be done during severe heat waves, assuming chalk has been applied in advance. A good supply of plant available calcium may help prevent/reduce losses to blossom end rot – through the drippers when plants are heat stressed.

Improving ventilation through fitting roof vents can help reduce heat and cool the leaves a little providing humidity is not reduced too much. Electric fans are another option, but will increase evaporation and water use by plants.

HUMIDITY

High humidity

When conditions are very cold the flower may be OK, but the fruit is not growing and if it is too humid in the greenhouse there may be cracking on the fruit. Even in warm weather if the humidity is too high on a cool night the fruit can start cracking, e.g if the temperature drops from 25^{0}C to 8 or 9^{0}C overnight.

When humidity is too high ventilation is required ASAP, except perhaps when you need to protect them from drought stress in very hot weather. In very cool weather open sides and ends to ventilate thoroughly around mid-afternoon, then close up ASAP to conserve any warmth still in the soil.

Low humidity

A young capsicum plant that has commenced setting in hot dry weather is at risk of dropping flowers if the humidity is too low. If you give a light watering from overhead sprinklers or misters this helps to raise humidity and reduce flower losses.

WARNING: This can only be used at the first flowering. If some fruit is already setting and ready to pick green it is too late. This fruit will rot/crack under excess humidity. However by this stage plants are larger and help to maintain the required humidity levels in the greenhouse anyway.

FRUIT OVERLOAD

Plants can only carry so much fruit before they stop growing and setting more. Two sets in winter is usually the limit before the plant begins to shut down. These plants will not move again until the mature fruit is removed.

The early signs of heat stress include; flowers dropping, fruit not growing, maybe leaf burning if the plants are really stressed.

FRUIT OVERLOAD CONTINUED...

The roots and leaves may weaken from being dormant and need to be stimulated to get going again if the weather conditions are not ideal.

HEAVY PRUNING

If heavy pruning of mature plants is carried out for some reason, e.g major chemical damage, this damage sends a hormonal message to the roots and they shut down in shock. Above ground the shoots will stop growing and no new flowers will form.

If conditions are good these plants may re-activate relatively soon, but can be helped by certain foliar applications to get the roots moving again.

NUTRITIONAL SUPPLEMENTS TO ASSIST RECOVERY

Once the damage is done it is important to correct whatever caused the stress (excess heat, water deficiency, nutrient deficiency etc.) as far as possible, but a damaged plant can reach a point where it presents a whole new set of management issues that need prompt direct action to help the plant recover and begin flowering and setting fruit again.

Apart from relieving any nutritional deficiency in the soil, some specific nutrients can also be used to help plants recover from stresses. This is because stress to plant roots or foliage changes the hormonal activity of plants which governs the uptake and use of nutrients for plant development. Under stress plants tend to shut down certain functions and can take time to 'wake up' again, especially if damage is severe or conditions are not favourable to plant growth.

Application of the right trace elements (to leaves to help root stress, and to roots to help leaf stress) that are in short supply in plant tissues can, to some extent help to override this induced deficiency and more quickly restore normal plant function and development. Early action is much more effective as a shut down can lead to other issues developing in an inactive plant, compounding the problem and making it harder to achieve a good recovery.

Some examples of using nutrients in this way are:

> NPK to an older pruned crop to help with this - through dripper. Do early after pruning
> Foliar iron when roots lazy
> Foliar zinc to help stimulate new growth

Winter cold:

> Fe on the leaves to help when roots slow in winter due to cold and cannot take up Iron
> Use some Phosphorous to prevent onset of lazy roots, use foliar in winter
> ZM^2 for recovery of plant vigour after cold weather – helps stimulate roots. Mg makes stronger stem and better sugar supply – a good general kick start.

Under stress plants tend to shut down certain functions and can take time to 'wake up' again, especially if damage is severe or conditions are not favourable to plant growth.

NUTRITIONAL SUPPLEMENTS TO ASSIST RECOVERY CONTINUED...

RELEVANT VIDEO, FACT SHEETS & RESOURCES:

> Greenhouse design and climate management (fact sheet)

> Using trace elements to help stressed plants recover (fact sheet)

06. ASSESSING RESULTS

The last 8 years of building healthier soils has enabled Phuong to drop from 6 to 5 rows per glasshouse and further apart. He has still been able to improve his overall yield by 67%, lift his percentage of first grade pick and reduce fertiliser costs!

He is now picking 20 fruit per plant or more even though hw has reduced his plant density.

Lower plant density has made spraying (time and coverage), picking, monitoring etc. much easier to manage. Reducing plant density by about 50% enables the whole system to work more freely and productively, including the grower!

He used to plant at 30cm between plants and 50cm between rows. Now he plants at 50cm between plants and 90cm (non picking rows) and 1m (picking rows). His plants are now bigger too and the variety has changed (from Clovis to Remy), perhaps making this more practical. Phuong has considered reducing his plant density further, but believes this would not maintain enough humidity.

Phuong has influenced many other growers to adopt similar practices with similar results and is now ready to adopt bio-control in his capsicum crop next season.

RELEVANT VIDEO, FACT SHEETS & RESOURCES:

> Mid crop review of plants, setting, feeding and pest control (video)

> End of crop review: yield, planting density, vegetative issues, pest control (video)

> Cost benefit-calculator (fact sheet & excel calculator)

> Phuong and SARDI researcher discussing benefits of compost (video)

Lower plant density has made spraying, picking, monitoring, etc. much easier to manage.

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