WHY GREENHOUSE PEPPERS?

Currently the major greenhouse crops grown in North America in order of importance are tomatoes, cucumbers, and lettuce. Recently many growers have been considering peppers as a viable alternative. The reasons are threefold: The introduction of colored greenhouse peppers to North America by the Dutch, the enthusiastic acceptance by the consumer and brokers and the high and stable price levels thus far achieved. The Dutch began importing peppers to the U.S. and Canada in 1982. Total volume for that year was 50,000 lbs. In 1986 over 11 million lbs. were imported. This is equivalent to 100 acres of domestic production.

Yields in Canada of 2½ to 3 lbs. per square foot at prices of $1.50 to 2.00 USD/pound coupled with an estimated 25% reduced labor requirement make peppers an interesting alternative to many growers. Because peppers are a new crop for most growers we have provided in this newsletter a brief growing guide.

SCHEDULING THE CROP

Since greenhouse peppers are a new crop for North America little information is available to advise growers on crop scheduling. Below are Dutch schedules which can be used as guidelines to predict sowing and harvest dates at different times of the year. These schedules are based on rockwool culture, careful adherence to optimum temperatures and cultural methods, and of course are influenced by Dutch light levels. In the U.S. or Canada, winter light levels will be much higher, but humidity levels may be lower and many growers will be planting into soil rather than rockwool. Despite these differences we think that the intervals between sowing and first harvest will be similar, provided the grower can maintain the optimum temperatures for transplant and early season growth as discussed below.

Seeding	Age of transplant (weeks)	Estimated first harvest of red or yellow fruit
Oct 1	8	Mar 15 - Apr 1
Nov 1	10	May 1
Dec 1	9	May 15
Jan 1	7-8	Jun 10
Feb 1	7-8	Jul 1
Jun 1	6	Oct 15
Jul 1	6	Dec 1

VARIETIES

Varieties are available in the colors of red, yellow, white, orange, brown and purple. Most of the popular varieties grown in greenhouses are of the sweet-block type. Red is the most popular color grown (80% of the acreage); followed by yellow (15%) and other colors (5%). Varieties differ in disease resistance,plant vigor, fruit size and shape, tolerance to blossom end rot, stip, russetting, cracking, shelf life and taste. De Ruiter's popular varieties in North America are: Red - CUBICO, LOCAS, and SPARTACUS; Yellow - SAMANTA, and GOLD FLAME; and Purple - DRS 3808. Please contact us for specific recommendations.

GERMINATION

Pepper seed can be sown in flats or plug trays filled with a good commercial soilless medium or rockwool blocks.

It is important that the medium be thoroughly wetted before sowing. After sowing, cover the seed with 1 cm of mix and water again overhead.

Cover the flats or plugs with a very low plastic tent to prevent drying. Do not allow the plastic to rest on top of the medium as this will restrict air movement and suffocate the germinating seed. Newspaper or similar material placed over the plastic will reflect radiation and help prevent excess temperature buildup on sunny days. Remove the tent as soon as germination starts.

The optimum media temperature for germination is 25-26 C (77-79 F). Germination time at these temperatures should be 8-10 days. Once the seed has germinated, slowly reduce the temperature to 23 C (74 F). Germination temperatures are best maintained by bottom heat.

TRANSPLANT RAISING

Once the cotyledons have expanded, the seedling can be transferred to 4-5" plastic pots filled with a high quality soilless mix or to rockwool blocks.

Optimum temperature for transplant raising are:

- Media temperature, bottom heat 20-22 C (68-72 F).
- Air temperature:
  Night - 21 C (70 F)
  Day - 21-23 C (70-73 F) +2C light dependent

Initially the plants can be spaced tightly to conserve space. The plants should be given a wider spacing once the leaves touch. This is essential to avoid stretching and premature leaf drop. The population during the last stages of transplant raising should be 16-20 plants/m2 (1.7-2 plants/ft2).

Fertilizer should be applied at every watering beginning 2-4 weeks from pricking-off (depending on the medium used). A mixture of potassium nitrate and calcium nitrate or a complete fertilizer such as 20-5-30 is adequate. The recommended rate is 1.5-2 g/liter fertilizer (EC 1.8-2.4 mmhos).

CO2 supplementation to 700 ppm will promote stronger and heavier transplants.

Staking the plant is not essential but will help keep the plants straight.

PLANTING OUT/GROWING ON

SPACING

The plants are ready to be placed in the greenhouse when they have reached a fresh weight of 35-40 g (1.2-1.4 oz). This should be 6-9 weeks after sowing, depending on the season and growing conditions.

In Holland, using the 2-stem training system, the optimum plant density is 6 stems/m^2 or slightly lower. This is equivalent to 3.58 ft^2/plant or 12,150 plants/acre. However, with our better light we suspect that a lower plant population is more ideal. Using the same spacing as for tomatoes is the logical approach until we have more research and experience. This spacing will give a slightly lower plant population.

When the 3-stem training system is used, the spacing should be increased accordingly.

Closer spacing than mentioned will have the following effects:

- higher yield, especially early in the season
- smaller fruit size
- higher plant costs
- more labor
- taller crop

TRAINING

As hinted at above, peppers can be trained to either 2 or 3 stems. The 2-stem system is most commonly used and is generally recommended. In the 3-stem system, the extra stem often lags behind the others, especially in very early crops grown under low light conditions. There may be a reduction in yield, and with the extra stem the crop may be more difficult to work in. The 3-stem system has the advantages of lower plant costs and shorter plants, however, and growers with low greenhouses may want to try it on a small scale.

Initially the pepper plant will develop a single stem. After 9-12 leaves, depending on the variety and light conditions, the plant will produce a flower bud, called the crown bud, and branch out into side shoots, usually 3. In the 2-stem system, the 2 strongest shoots are left and any others are topped after the 1st leaf or removed completely to

allow more air circulation. Any side shoots developing later must also be topped, usually after the 2nd leaf.

The shoots should be trained along a string, similar to tomatoes. The strings must be tied loosely around the shoots so that girdling will not occur. There should be some slack in the string to allow twisting, but not so much that the stems sag sideways.

Many experienced growers will tie the stems as late as possible, just before the plants begin to sag, so workers do not have to stoop as far and less string is required. Waiting too long may cause a backlog in the workload. Experience will teach what will be the best time. For new pepper growers, it is probably best to play it safe and not wait too long with tying the stems.

TEMPERATURES

Media Temperature

Warm media is essential for establishment and good initial growth. The media temperature should be at least 20°C (68°F). If the temperature is too low, growth will be slow and pythium may attack.

Air Temperature Phase I: Early plant growing in greenhouse

Peppers are by nature slow growing and demand a high temperature to develop reasonably quickly. Maintaining high temperatures early in the crop will promote vegetative growth and postpone fruit set until the plants have reached adequate size to support a fruit load.

For good growth the 24 hour average temperature must be approximately 21°C (70°F). This is generally attained by maintaining a night temperature of 20°C (68°F) and a day temperature of 23°C (73°F).

Air Temperature Phase II: Fruit Setting

Two to three weeks before fruit set, the 24 hour average should be lowered very gradually by reducing the night temperature to 17-18°C (63-65°F). The day temperature should remain at 23°C (73°F).

Thus, once the fruit has set, the night temperature should be 17-18°C (63-65°F) and the day temperature 22-23°C (72-73°F), with a resulting 24 hour average of about 20°C (68°F). If stronger flowers are desired to improve fruit set, the night temperature can be lowered a little. If faster fruit development is desired, the temperature can be increased. This is sometimes done after the initial fruit set.

If the 24 hour average is too low, it will take much longer for the peppers to ripen. This will have a negative effect on quality, as older fruit are more prone to disorders such as russeting.

If the 24 hour average is too high, the flowers are affected and produce smaller, more misshapen fruit. The ventilation setpoint is usually 1-2°C above the heating setpoint. Temperatures higher than 30°C (86°F) should be avoided. This will probably necessitate shading in the summer.

RELATIVE HUMIDITY

The optimum relative humidity (RH) for peppers is 70-80%. This is needed particularly right after planting to ensure good establishment and growth. During the winter months and while the plants are small it is often difficult to maintain the RH at the desired levels. Much of the humidity condenses on the glass in the winter, and small plants transpire only a limited amount of water vapor to the air.

The most common method in Holland for improving the RH in the winter is the use of a temporary plastic screen. The plastic is very thin (2 mil) and has been treated to avoid the formation of condensate droplets (anti-condensate or no-drip film). The screen stays in place day and night for up to 8 weeks. When the RH threatens to become too high (>80%), the screen is opened in places to allow moisture to escape. Later in the season, the screen is removed entirely. Besides the increase in RH, there may be a considerable energy savings. The disadvantage of using a screen is the risk of snow accumulation on the roof.

Another method for improving RH may be the use of an overhead fogging system. There is a potential problem with moisture condensing and freezing on the glass. The use of fogging systems will have to be investigated further.

FRUIT SET

As a general rule, fruit set should be delayed until the 3rd or 4th axil of the side shoot. If fruit sets occurs too early, vegetative growth will slow down severely, the fruit will not size, and quality problems such as blossom end rot and russeting can be expected.

Flowers will not set under poor light conditions and high temperatures. To stimulate fruit set, the temperature must be reduced as described earlier under the section on temperatures.

Light conditions may be such in December and January that the crown flower and/or flowers in the lst few axils will set in spite of the high temperature regime. Should this be the case, the flowers/fruits must be removed as early as possible.

FRUIT THINNING

Thinning to 4-6 fruit on the first flush will increase the size and result in a higher total yield (the very early yield may be reduced somewhat). After the first flush, thinning should be limited to the removal of misshapen fruit. Additional thinning is labor intensive and may increase russeting.

CO2

As with other horticultural crops, supplementing with CO2 is recommended. The optimum concentration is 600-800 ppm. When the ventilators are open, ambient (340 ppm) CO2 levels should be maintained.

High concentrations may cause crop damage. Special care must be taken to avoid this when plastic screens are used.

IRRIGATION

Immediately after planting, relatively little water need be applied to the crop. As the crop grows and the season progresses, the water requirement increases. A fully grown crop can take up as much as 6 liters/m^2/day (½ gal/plant/day). In this regard, peppers do not differ from tomatoes or cucumbers.

NUTRITION

Soil Growers

Peppers are salt sensitive, making the use of good quality irrigation water very important.

If the greenhouse soil has been steamed and subsequently leached, the nutrient levels will be rather low. Application of a base dressing prior to planting may be required. The following table can be used as a guide.

Fertilizer	Amount to apply (kg/100m^2)
Calcium nitrate	0 - 10
Sulphate of potash/magnesia	0 - 12
Epsom salts	0 - 6
Triple super phosphate	0 - 15

These amounts are based on full field application and must be worked in to depth of at least 25 cm. The actual amounts to be applied will depend on the nutrient status of the soil. A soil test is therefore required. If soil test results are not available and if the soil has been leached moderately well, amounts in the range of 50-70% of the top values listed will probably suffice.

If the crop is fertilized through a drip irrigation system, a thorough base dressing will be less critical. Soil tests will be needed throughout the season to ensure appropriate availability of nutrients. The following table lists the recommended values of the 1:2 volume extract as used in Holland. The corresponding values for the saturation extract are given in the third column.

Element	1:2 vol. extr.	S.E.
Nitrogen (N)	4.5 mmol	180 ppm
Potassium (K)	2.0	170
Magnesium (Mg)	1.2	90
Calcium (Ca)	2.5	330
Phosphate (P)	0.15	5
Sulphate (SO4)	2.0	700
EC (mmhos)	1.5	3.5

Depending on the base dressing, liquid feeding may not be required for the 1st few weeks. When fertilizer is applied to the crop via the

irrigation system, a concentration of 1 g fertilizer/liter of water can be used. This is about an increase of 1 mmhos in the EC of the irrigation water. Such a concentration will maintain the nutrient levels in the soil. The concentration may have to be increased or decreased depending on the soil test results and the appearance of the crop.

For liquid feeding, often the 2 stock tank system is used, in which the fertilizers are dissolved in 200x concentration. The general formula for soil growers is as follows:

Tank A	kg/1000 liters
Calcium nitrate	80
Potassium nitrate	40
Tank B	
Potassium nitrate	50
Epsom salts	55
Mono ammonium phosphate	10

At a dilution of 1:200 there will be approximately 1.2 grams fertilizer per liter for an EC increase (over the city or well water) of 1.3 to 1.5. At these levels, ppm of the various elements will be:

N	130 ppm
P	15
K	170
Ca	75
Mg	30
SO4	40

Many growers will need to use acid to reduce the pH of the irrigation water. Phosphoric acid is recommended for this purpose and when it is used, monophosphate can be eliminated from Tank B.

It must be made clear that the above formulae are to be used with good quality water, such as rainwater or city water. Well water or water from ponds may contain significant amounts of calcium, magnesium, sulphate, etc. The fertilizer formula must be adjusted to take this into account when this type of water is used.

Rockwool

Nutrition guidelines for rockwool growers can be obtained from your rockwool dealers.

HARVESTING

Harvest peppers with a sharp knife in the morning when the fruit are still cool. Warm fruit will become soft sooner. The use of a knife will leave a smooth surface on the stem, which adds to the appearance and reduces the incidence of botrytis in the crop.

Pepper fruit will continue to color after harvest, so some green on the fruit at picking is acceptable. The fruit must be fully red or yellow at the time of sale. Coloring will be faster at higher temperatures and therefore more green is allowed at harvest during the summer.

Harvesting crates should be lined with foam. Peppers should be placed in the containers, not tossed from a distance, to avoid damage to the fruit. The peppers should not be exposed to full sunshine and should be shipped to the packing/shipping area as quickly as possible.

High plant vigor can be controlled by leaving some fruit on the plant.

FRUIT DISORDERS

BUTTONS

Buttons are severely misshapened peppers which contain few or no seeds. They are usually short and small. Buttons can often be detected during bloom - generally the large, coarse flowers that bloom over a long period will produce buttons. Low daytime temperatures, low RH, and/or overly vigorous plants can all result in buttons. If the fruits on the first set are all picked at one time this may result in vigorous growth and later development of buttons.

RUSSETING

Russeting is the occurrence of small cracks in the outer fruit wall. The cause of russeting is not yet well understood. A number of factors apparently contribute to this disorder.

The tail end of a heavy set is likely to be russeted. Once the first fruits of a flush are harvested, the remaining fruits get an extra "push". An already tough skin will not be able to absorb the extra swelling and will crack.

Other factors which may contribute to russeting are low EC of the soil moisture, condensation, RH and a large difference between day and night temperature. Periods of cool, dark weather are known to cause an increase in russeting.

PITTING

Pitting occurs primarily on ripe peppers and is caused by small concentrations of dead cells in the fruit wall. Pitting occurs primarily when weather conditions favor strong vegetative development. Affected fruits have a higher calcium content. It is expected that pitting will not be a serious problem under Ontario conditions.

INTERNAL GROWTH, WINGS, AND TAILS

Internal growth is abnormal development of honey glands on the inside of the fruit. It can occur during the first flush. In serious cases, it may even cause the fruit to burst.

Wings are also honey glands, developing from the calyx.

Tails develop at the flower end of the fruit from parts of the style that did not die. Tails break off easily during harvest and handling, leaving a wound where rotting can start. A long flowering period, caused by low temperatures, is thought to be one of the contributing factors.

SHOULDER CRACKS

Shoulder cracks are fresh, open, wet wounds caused by irregular transpiration and water uptake just before harvest. Reduced transpiration due to poor weather, too much water, or a sudden reduction in EC may cause shoulder cracks. Yellow peppers are particularly sensitive.

BLOSSOM END ROT (BER)

BER can be a serious problem. BER is caused by too high temperatures, too high salt concentrations, low calcium, and/or low RH.

GRADING AND STORAGE

In Holland peppers are graded to size as follows:

	Distance across the shoulder	
Small	55-65 mm	2.2-2.5 inches
Medium	65-75	2.5-3.0
Large	75-85	3.0-3.3
Extra Large	>85	>3.3

Peppers should be stored at 7-8°C (45-47°F). Temperatures below 5°C (41°F) will cause damage. The storage temperature will affect the rate of coloring:

	No. of days to reach 100% color at indicated temperature									
	Yellow peppers					Red peppers				
Harvested	°F					°F				
at	46	54	60	68	75	46	54	60	68	75
50% green	24	16	11	8	10	17	10	9	9	11
30% green	23	13	9	7	7	13	9	8	8	10
10% green	16	10	6	6	4	10	8	7	7	7