zero, because there is no light. So at night there is no pronounced water gradient in the plant as in daytime. Nevertheless, there is some water movement, because the root system actively takes up water and pushes that upwards. This way of water uptake is sometimes called root pressure. This water flow takes place also in the xylem vessels, like the transpiration flow, and it does contain Ca. An important difference with the uptake by transpiration during daytime is that at night water is forced into all plant organs: stems, leaves, buds and fruit. This water flow makes the fruits swell and provides them with some calcium.

A high air humidity at night reduces the loss of water vapour by the leaves and thus helps to build up a high water pressure in the plant, which pushes more xylem sap into all plant parts. A high air humidity at night therefore has a positive effect on the Ca content of tomato fruit.

However, the total water uptake at night is only a small fraction of the water uptake at daytime, when there is large transpiration flow. Hence the overall effect of night air humidity on Ca supply to fruit and thus on BER is only small. A significant Ca deficiency developed in a fruit during the day cannot be compensated for completely during the night.

Effects of growth rate on the incidence BER

As stated in the introduction, the incidence of BER is related to the uptake of Ca relative to the demand of Ca by the fruit. The demand for nutrients is greater in a rapidly growing fruit than in a slowly growing fruit. Fruits grow fast because they receive good supplies of sugar by the phloem sap, which is unfortunately low in Ca. So by definition, a rapidly growing fruit gets much sugars, sufficient water and very little Ca, so it will likely be at risk for BER.

This explains why BER is more of a problem under high light conditions: then the photosynthetic activity of leaves is high, so the sugar production in the leaves is high, and the significant phloem stream with sugar makes the fruit grow rapidly. Because the phloem stream contains little Ca, the growing fruit receives insufficient Ca for all the new cells that are formed, and BER arises.

Fruit thinning might have a similar effect, as removing some fruits will increase the growth rate of the remaining fruits, which may enhance the incidence of BER.

BER as influenced by environmental factors

The conditions that influence BER can be summarised as follows:

(water availability: water shortage in the root zone obviously limits the uptake of water and nutrients such as calcium (Ca), and gives rise to blossom-end rot (BER);

(calcium availability: the lower the Ca concentration in the root zone water, the lower the Ca uptake, and the higher the risk for BER;

(salinity: the higher the salinity in the root zone, the lower the uptake of water and nutrients such as Ca, thus the more BER;

(root zone temperature: a too low root temperature (both during the day and the night) reduces root activity: the resultant Ca uptake might be too low, and the incidence of BER higher;

(air temperature: higher temperature stimulates plant growth and transpiration and hence increases the incidence of BER. Moreover, high temperatures often go together with high radiation and low air humidity, which both have a great impact on the incidence of BER;

(radiation: a high light intensity increases the fruit growth rate and hence the Ca demand; when fruits receive less Ca than required, the incidence of BER increases. High light levels also increases the transpiration rate. High transpiration favours the Ca supply to the leaves while reducing the Ca supply to the fruits, thus increasing the incidence of BER;

(air humidity at day: also low air humidity increases the transpiration rate (see at radiation).

(air humidity at night: a low air humidity at night reduces the water pressure that is built up in the plant and hence reduces the amount of calcium-containing xylem sap pushed into the fruit. This also may slightly enhance BER. However, air humidity at night has less impact on BER than air humidity during the day.

Strategy to reduce the incidence of BER

The main option for reducing the risk of BER in tomato is to secure an adequate supply and uptake of both water and calcium, particularly under high light conditions. For good uptake, the root system must be well developed during periods prior to extreme summer conditions. This can be achieved by stimulating transpiration through using extra ventilation in that period. The concentration of Ca in the root zone must be sufficient and well balanced with that of competitive cations.

Although high light conditions imply increased risk of BER, reducing incoming radiation by using shade cloth or whitewash is not recommended, as either practice will directly reduce both plant and fruit growth rates. It is better to prevent extreme transpiration while maintaining high rates of photosynthesis and growth. Transpiration can be reduced by increasing air humidity through the use of sprinklers on the roof or good fogging or misting equipment. Misting or fogging must not make the plants wet for any period of time, as wetting increases the risk of fungal diseases and may reduce photosynthesis. The feasibility of misting or fogging depends on prevailing conditions and costs, and must be tested and evaluated. At night, increasing the air humidity by reducing the ventilation, may reduces BER to a small extend.

I am indebted to the manufacturer of PlantPlan computers (Mosaic Systems Ltd., P.O.Box 914 Palmerston North; P.O.Box 8238, Auckland) for partial funding my research on greenhouse climate control.

Minimising onion soft rot

by **P J Wright**, Crop & Food Research, Pukekohe

Post-harvest decay has been a serious problem affecting onions grown in the Pukekohe district for many years. Bacterial soft rot of onion is of particular concern to the New Zealand onion industry because of the complexity of the disease and the threat to valuable export markets. Infected bulbs are not easily detected at grading and the shipment of diseased bulbs has occurred previously. No effective chemical control measures have yet been developed to combat the disease, and although onion cultivars and breeding lines are known to vary in susceptibility to bacterial soft rot, none are yet considered resistant. Soft-rotting bacteria survive on infected plant debris in the soil and are generally recognised as opportunistic pathogens that invade onions through wounds when conditions favour infection.

Nitrogen (N) fertiliser applications and irrigation frequency can influence the storage quality of onion bulbs by affecting onion growth. Work carried out overseas demonstrated that a high incidence of rots occurred in bulbs of onion plants that received excessive N and were irrigated late in the growing season. The necks of these onions were thicker and more succulent than non-irrigated onions that received lower rates of N, and the necks did not dry completely during curing. Onions with thick necks are more likely to be wounded when the foliage is removed at harvest (topping), and consequently, become highly susceptible to invasion by soft-rotting bacteria. In New Zealand, local onion growers use a wide range of fertilisers and application schedules, although the effects of fertilisers on the incidence of rots in locally-grown onions has not been fully investigated.

The severity of soft rot incidence in stored onion bulbs can be influenced by the weather conditions prevailing over harvest as soft-rotting bacteria require moisture for infection. Wet weather during field-curing slows down the evaporation of water around the onion plants and, as a result, an increased incidence of diseased bulbs can occur.

Damage to bulbs during lifting curing and harvest can also result in an increased incidence of infected onions as many pathogens can enter the bulb via wounds. In store, pathogenic bacteria from rotted bulbs can infect other bulbs that are damaged or wounded, although it appears unlikely that they are able to infect healthy bulbs. Soft rot bacteria reproduce rapidly at temperatures above 25oC and at high relative humidity, but once inside the bulb do not require high humidity to continue infection.

A trial was carried out by Crop & Food Research staff at Pukekohe in the 1991/92 season to investigate the effects of nitrogen fertiliser, onion maturity at lifting, and water during field-curing on the incidence and severity of bulb rots in storage. In June 1991, seed of onion cv. Pukekohe Longkeeper were direct-seeded using a "Stanhay" precision seed planter in 15 five-row beds 31m long and 1.5m wide. Plant density was 55-65 plants per metre of bed. A base fertiliser application of 15% potassic superphosphate (1 t/ha) was applied to the experimental site 1 month prior to planting. Weeds, fungal diseases, and insect pests were controlled as in local commercial practice.

Peter Wright

To examine the effects of different N rates and application times on the incidence of bacterial soft rot of onions in store, five N treatments were applied. For each treatment, N, as urea (46 % N), was applied in equal quantities (split application) on two occasions (Dates A, B, or C). Date A was early crop emergence, Date B was 8 weeks after Date A, Date C was 8 weeks after Date B. A common practice in the Pukekohe district for N, as urea, to be applied at 120 kg N/ha in equal split applications at early crop emergence and 6-8 weeks later.

To determine the effects of the physiological maturity of onion plants on the incidence of storage rots, bulbs were lifted on two occasions. On 30 January 1992, half of the onions in the trial were lifted when between 50 and 70% of the plants had collapsed foliage (top-down), and the other half were lifted on 19 February 1992 when they had >90% top-down. Onions lifted on both occasions were left on the ground to dry (field-cure) for 22 days.

To test if wet conditions over field-curing affected the incidence of storage rots, the experimental site was divided at right angles to the beds into two equal portions, with one portion subjected to overhead irrigation during field-curing. Each treatment was replicated 5 times in a randomised block design in each water treatment. Plots were 2m long and a buffer zone of 1m separated the plots.

After field-curing the onions were bagged in the field then transported to the packing shed where the tops were mechanically removed. The bulbs were put in nylon string bags and stored at ambient temperatures and humidity in an unheated shed. Disease severity was assessed two months after harvest when all onion bulbs were cut longitudinally and examined for soft rot.

Rainfall recorded during field-curing was 73 mm for onions lifted at 50-70% top-down, and 32 mm for onions lifted at >90% top-down. The effect of additional water over field-curing on the incidence of bacterial soft rot of onions in store was considerable as the percentage of rots was significantly higher in bulbs that were irrigated over field-curing than in non-irrigated bulbs (Table 1 over the page). N rates and application

Next page

times also influenced the levels of rotted bulbs in both water treatments. Time of lifting did not affect onion soft rot incidence as there were no significant differences in levels of diseased bulbs of onions lifted at either 50-70% top-down or at >90% top-down in both water treatments when N treatments were compared.

Water Treatment		No additional water		Supplementary water	
Nitrogen (Kg N/ha)	Application times	Early lifting	Late lifting	Early lifting	Late lifting
Nil		1.0	2.0	2.4	2.8
120	Dates A & B	1.2	2.0	2.0	3.2
240	Dates A & B	1.2	1.6	5.6	7.2
120	Dates B & C	2.0	2.4	7.2	6.0
240	Dates B & C	3.6	3.2	8.2	7.2
Water treatment means:		2.0		5.0	

Table 1. Effect of nitrogen rates and application times, lifting time, and water over field-curing on the incidence of bacterial soft rot in stored onion bulbs. Results are expressed as percent of rotted bulbs.

Where onions were not given additional water during field-curing, the levels of rots in store were highest in onions that were given N late in the growing season. Onions that were given 240kg N/ha on dates B & C had more rots than bulbs of onions in the other N treatments. The lowest incidence of soft rotted bulbs was in onions that were not supplied with N during the growing season and lifted at 50-70% top-down. The highest incidence of storage rots occurred in onions that were given 240 kg N/ha on dates A & B and lifted at 50-70% top-down.

When additional water was applied over field-curing, fewer rots occurred in onions that were given no N or 120kg N/ha on dates A & B than in onions in the other N treatments. When N was applied on dates A & B, onions that were given 240kg N/ha had more rots than onions that were given 120kg N/ha. However, there were no noticeable differences in rots in onions that were given either 120kg N/ha or 240kg N/ha on dates B & C. The lowest incidence of rots was in bulbs of onions that received 120kg N/ha on dates A & B and were lifted at 50-70% top-down, and the highest incidence of rots was in bulbs of onions that received 240kg N/ha on dates B & C were lifted at 50-70% top-down.

The results of this trial clearly illustrate that the quantity of N given to onion plants, the time of application, the physiological maturity of onion plants at lifting, and the prevailing weather conditions over field-curing are critical factors affecting the incidence of storage rots of PLK onions.

Over-fertilisation with N, or the application of N late in the growing season can result in increased numbers of onions with storage rots, especially if conditions are wet over field-curing. N applied in this manner often causes bulbs to develop thick necks which are prone to wounding when topped. Wounded bulbs are more likely to be invaded by soft rot bacteria.

Onion growers can reduce the incidence of soft rots in stored bulbs by crop rotation, and by the modification of husbandry practices. In order to minimise the opportunities of soft-rotting bacteria infecting bulbs through wounds, onions should be lifted when they are fully mature (>90% top-down) and dried as quickly as possible. Ideally, onion plants should be lifted when fine weather is forecast during the field-curing period. However, if rain is imminent during field-curing, bulbs should be moved to a dry, well ventilated shed and allowed to completely cure before being topped. If storage rots of onions are to be further controlled, local growers may need to artificially cure bulbs.

Careful handling during harvest and grading to avoid cuts and bruises is essential to minimise losses from storage rots as damaged bulbs are more likely to be infected by pathogenic bacteria. At grading, bulbs should be closely examined and any that are diseased, immature, or have thick necks should be discarded. Because the presence of free water on onion bulbs and temperatures over 25oC favour infection by soft-rotting bacteria, bulbs should be stored at 2-8oC and below 75% RH in well-ventilated stores.