EFFECT OF CALCIUM ON TIPBURN OF LILIUM 'PIRATE'

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Abstract

A typical kind of tipburn is observed in Lilium 'Pirate'. Leaves of the upper part of the plant have white-grey cross bands about 2 cm from the tip caused by collapse of one layer of palisade parenchyma cells just under the epidermal layer. Symptoms become visible before the flower buds can be seen, usually when the plant has reached a length of 30 to 40 cm.

A high relative air humidity increases tipburn. Plants grown without stem roots also show more symptoms. Removal of the lower leaves just after unfolding decreases tipburn. Severe tipburn is found on plants grown in hydroculture with a low calcium concentration in the nutrient solution. Higher concentrations of calcium decrease tipburn, but can not prevent it.

Tipburn decreases when plants are repeatedly sprayed with solutions of calciumchloride or calciumnitrate just before the susceptible stage. In most cases 68 mM $CaCl_2.2H_2O$ reduced tipburn to an acceptable level. In some cases concentrations up to 204 mM are required, which, however, may damage the leaves and cause browning of the tips. Not only calcium, but also strontium and manganese are effective. This indicates that instability of cell membranes is the cause of tipburn.

1. Introduction

Many new hybrids of Asiatic lilies may show a typical kind of tipburn. The leaves show white-grey cross bands at about 1-2 cm from the green tips. In the Netherlands this was first observed in the mid-seventies in 'Pirate'. This cultivar originated from a cross involving Lilium cernuum, which also shows this kind of tipburn.

Tipburn or leaf scorch has been well documented in Lilium longiflorum (e.g. Stuart et al., 1952; Marousky and Woltz, 1977). Leaves in the lower part of the plant have necrotic tips or in some cases semicircular necrotic regions along the margin of the leaves. This type of tipburn is also found in Asiatic hybrids and has been ascribed to fluoride damage (Roorda van Eysinga, 1980).

Tipburn as found in 'Pirate' is different, however. It is only found in the upper part of the plant and varies from some small white-grey spots on a few leaves to wide bands on almost all leaves of the upper third part of the plant. In all cases, however, the tip of the leaves is still green. In severe cases tipburn may eventually result in decay of the top of the plant, probably caused by secundary infections, leading to complete loss of the flower buds (van Nes, 1979).

It can be found year around under all climatic conditions, although symptoms are more pronounced in sunny wheather (van Nes, 1979). On the other hand a high relative air humidity obtained by covering the plants with plastic foil caused very severe tipburn (van Nes, 1980). Calcium levels in leaves with tipburn were lower in affected than in healthy leaves. Neither addition of calcium to the soil, nor a single spraying with calcium nitrate on the plant decreased tipburn, however (van Nes, 1978).

The present investigation was undertaken to obtain more information on factors causing tipburn and to find ways for prevention.

2. Material and methods

Bulbs of Lilium 'Pirate' (14/16 cm circumference) were planted in 14 cm pots in ordinary garden soil. Experiments were done in a glasshouse at a minimum temperature of 17^{o}C. For hydroculture, bulbs were planted in pots with light expanded clay aggregates and placed in 2 to 3 cm of a nutritional solution containing 0.8 $g.l^{-1}$ Nutriflora T with all minerals except calcium and nitrate. Nitrate was added as KNO_3 (4.2 mM), calcium as $CaCl_2.2H_2O$ (0.8, 4.2 and 8.4 mM). Plants were sprayed with solutions as indicated in results by a hand vapourizer till drops fell off the leaves. Tween 20, 1 $ml.l^{-1}$ was added as a wetting agent.

Anatomical studies were made of fresh material. Sections were made by hand with a razor blade and cleared by Herr's clearing solution (Herr, 1971).

Tipburn was observed at flowering time and expressed as the percentage of plants with symptoms. The tipburn score (TB-score) approximately expresses the number of leaves with symptoms of plants showing tipburn.

3. Results

3.1. Morphological and environmental studies

The first sign of tipburn is a curling of the leaves in the top of the plant. After one or two days white-grey cross bands become visible at 1-2 cm from the tip of the leaves (Fig. 1). Anatomical studies show that the palisade parenchyma cells just under the epidermal layer have collapsed. Both the epidermal layer and the spongy parenchyma cells are not affected. Symptoms can vary from a few spots on one single leaf, to bands of several cm's on almost all leaves in the upper part of the plant. The bands can be seen when the plant has reached a length of about 30-40 cm, just before the flower buds become visible. At this period, growth rate is maximal at 3-5 cm daily.

Removal of the roots before planting has no effect on tipburn. However, prevention of stem root development by planting the bulbs at soil surface increases tipburn (Table 1). Plants grown at a relative air humidity of above 95% obtained by covering the plants with plastic foil show very severe symptoms of tipburn with a decay of the top in almost all plants. Removal of about half of the lower leaves just after unfolding decreases both the number of plants with tipburn and the TB-score (Table 2).

3.2. Effects of calcium

Bulbs grown in hydroculture with a low level of calcium (0.8 mM) show more tipburn than bulbs grown on a calcium level of 4.2 or 8.4 mM. There is, however, no difference between the two higher concentrations. Soaking the bulbs for 24 hours in solutions of 136 mM or 272 mM of $CaCl_2.2H_2O$ before planting also has no effect on tipburn.

Sprayings with solutions of calciumchloride or calciumnitrate reduce tipburn (Table 3). In both experiments the plants were sprayed daily from a length of 25 cm, 1 or 2 days before the first symptoms were expected, until the flower buds became visible. In total the plants were sprayed about 8 times. Both the number of plants with symptoms and the TB-score decreased. The number of flowers, the length of the plant nor keeping quality were affected. In a third experiment bulbs of two different origins were used which show a different susceptibility to tipburn (Fig. 2). Both origins, however, show a positive effect of sprayings with calciumchloride on the prevention of tipburn, although calcium concentration must be about 3 times higher for plants of origin II to reach the same effect as with plants of origin I. This high concentration, however, resulted in browning of the leaf tips, probably caused by salt damage.

In some experiments plants were treated with calciumchloride on one side only. On this side, tipburn was observed on considerably less leaves than on the non-treated side. Drops of calciumchloride solution put on the leaves in the susceptible stage cause in some cases green islands in the white-grey cross bands several days later.

Daily sprayings with strontiumchloride or manganesechloride also reduce tipburn, although less effectively than calciumchloride (Table 4).

4. Discussion

Tipburn in Lilium 'Pirate' was shown to be a result of breakdown of one cell-layer just under the epidermal cell-layer. In our experiments which were done year around, we did not observe a relation to climatic conditions as reported by van Nes (1979). There is, however, a difference in susceptibility between bulbs of different origins, the cause of which could not be established.

Tipburn can be prevented by repeated sprayings of solutions with calciumsalts. Calcium was applied daily from just before the first symptoms until the flower buds became visible. Sprayings every other day were almost as effective as daily sprayings (Berghoef and Elzinga, 1982). Results, not presented here, showed that a single spraying is not effective, as was also found by van Nes (1978). These results indicate that during the susceptible period, which coincides with the period of the highest growth rate, a calcium deficiency in the young upper leaves may arise.

A deficiency of calcium can be caused by insufficient uptake or inadequate transport to the growing leaves. Uptake of calcium is probably not the limiting factor as the results show that tipburn can not be prevented by increasing the supply of calcium to the roots beyond a minimum level, as was also found by van Nes (1978). Moreover, soaking the bulbs before planting in solutions of calcium also has no effect on tipburn.

Transport of calcium to the growing parts can mainly be attributed to the transpiration flow or to root pressure (Bangerth, 1979). Both factors may be of importance in 'Pirate'. The absence of stem roots, which mainly support growth after emergence, causes an increase of tipburn. Analysis of stem root development during growth show that at the susceptible stage only one circle of stem roots is fully developed, while usually three circles can be observed when the flower buds become visible.

The importance of transpiration is shown by the dramatically increased tipburn when plants are grown at a high RH. However, climatic conditions with a normal RH of about 70% also cause tipburn. Moreover, removal of the just unfolded leaves, which doubtlessly decreases transpiration of the whole plant, reduced tipburn. During the susceptible stage the young upper leaves are still densily packed at the top of the plant and will, therefore, show a low transpiration rate. Transpiration flow will be directed mainly to the older, unfolded leaves. The same phenomena has been observed in other plants with densily packed leaves (e.g. Wiebe et al., 1977; Kuo et al., 1981). This may also explain why the tips of leaves with tipburn remain green, as these tips are more exposed and therefore have a stronger transpiration.

The physiological role of calcium in plants is very diverse. It has been shown that both Mn and Sr can reduce tipburn in 'Pirate' just as Ca. This indicates that tipburn is caused by an impaired cell membrane function (Bangerth, 1979).

5. References

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Table 1. Effect on tipburn of the presence of stem roots.

	% plants with tipburn	TB-score	n
control	68	40	22
no stem roots	100	60	22

Table 2. Effect on tipburn of leaf removal after unfolding.

% of removed leaves	% of plants with tipburn	TB-score	plant length at flowering (cm)	n
0	63	37	58	30
46	18	15	50	28

Table 3. Effect on tipburn of daily sprayings with calciumchloride or calciumnitrate. Sprayings started at a plant length of 25 cm.

	Control	$CaCl_2.2H_2O$			$Ca(NO_3)_2.4H_2O$		
		32	68	136	32	68	136 mM
Experiment 1							
% plants with tipburn	87	42	19	0	39	43	-
TB-score	30	14	13	0	16	15	-
n	31	31	32	40	31	27	-
Experiment 2							
% plants with tipburn	51	40	19	7	-	20	17
TB-score	22	6	8	3	-	9	8
n	34	35	34	35	-	35	24

Table 4. Effect on tipburn of sprayings with $SrCl_2$, $MnCl_2$ and $CaCl_2$.

	% plants with tipburn	TB-score	n
Control	88	57	58
$CaCl_2$ (68 mM)	6	50	34
$SrCl_2$ (68 mM)	19	51	47
$MnCl_2$ (68 mM)	48	24	42

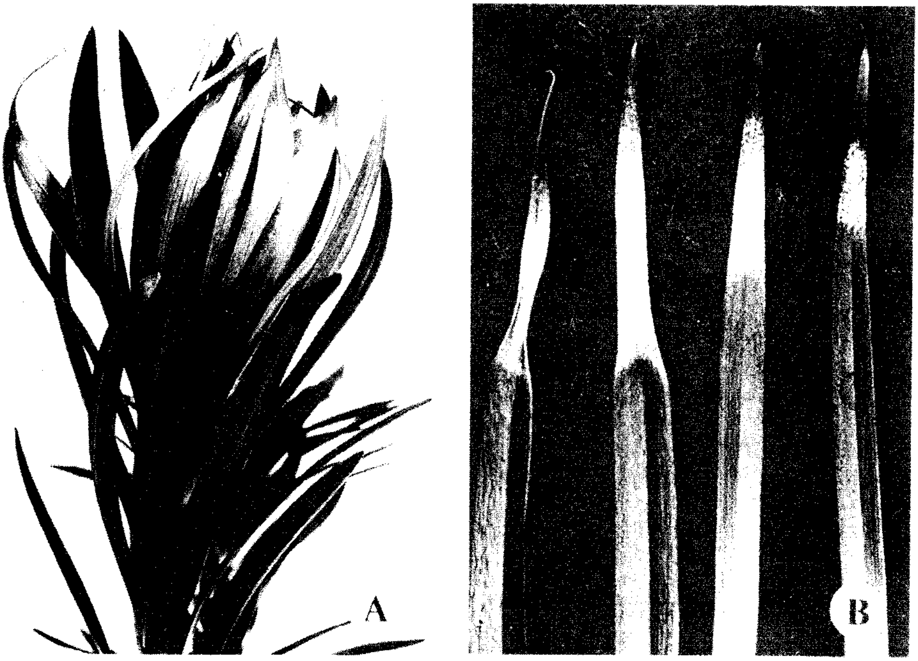

Fig. 1 A: first sign of tipburn, curling of the leaves
B: leaves with symptoms of tipburn

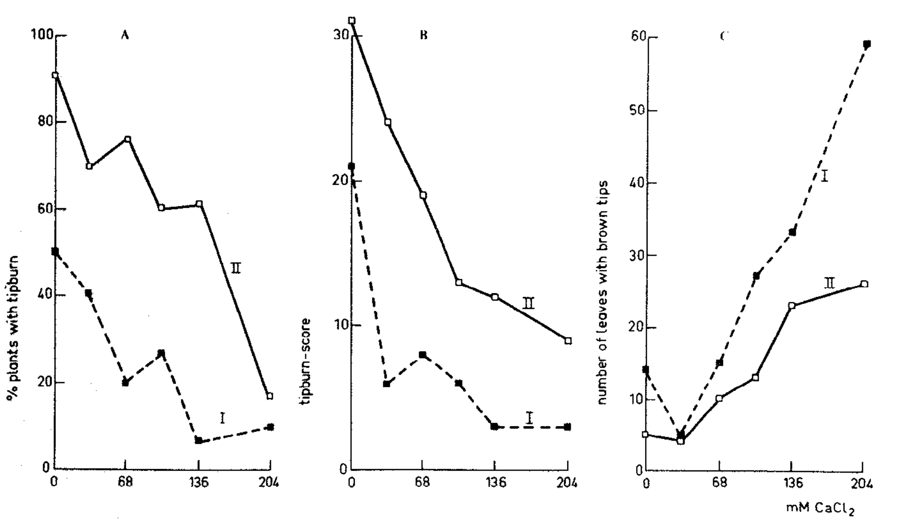

Fig. 2: Effect of daily sprayings of $CaCl_2$ on % plants without tipburn (A), TB-score (B) and number of leaves with brown tips per plant (C). I and II are plants from bulbs of different origin.