HDC PC6 Annual Progress Report - 1987/88

The effects of humidity on growth of tomato, cucumber and poinsettia

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Location : IHR, Littlehampton

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Robert Askew was appointed to work on this project from 18 May 1987. He has spent some time reviewing the literature on the topic and meeting with growers of tomato and poinsettia to familiarise himself with current cultural practices and to discuss the research they would like done. He has also had discussions with ADAS staff at the Efford and Lee Valley Experimental Horticulture Stations and has made visits to Efford EHS to assist in the collection of data from the humidity experiments in M Block.

His work at Littlehampton has been principally concerned with the effects of controlled levels of humidity, and their interaction with controlled levels of other environmental variables, on plant growth and development using artificially-lit controlled environment cabinets. This work has concentrated on three main aspects; the effects of humidity on tomato; the effects of humidity on poinsettia, and the measurement of transpiration.

Tomato

Two different leaf disorders have been observed with tomato plants grown at high humidity. When grown at a vapour pressure deficit of 0.1 kPa (c. 96% r.h. at 18°C), the emerging leaves of tomato reach a smaller final size than those at 0.8 kPa (c. 61% r.h. at 18°C) and they develop a pale yellow-green border associated with low calcium concentrations in the leaves. Transpiration (the loss of water from leaves) was much less at high humidity and it is inferred that, as calcium moves only in the transpiration stream, high humidity prevents sufficient calcium from reaching the young, rapidly expanding leaves. Calcium is required in cell division and expansion, and so the first symptom of deficiency is reduced leaf area. A more serious deficiency causes disruption of the cell membranes of the photosynthetic system, leading to chlorosis and death of tissues.

Measurements of leaf size on crops grown at different humidities at Efford EHS showed that leaf area was reduced by up to 50% in those leaves that developed during exposure to high humidity. Fruit trusses that developed in the vicinity of the affected leaves yielded smaller fruit. Prolonged exposure to high humidity, therefore, should be avoided, and it should soon be possible to issue practical recommendations.

The second disorder appears more commonly when plants are grown under artificial light sources at high humidity. Under these conditions, leaves develop small (1-2 mm diam.), yellow-green pustules on their upper surfaces, between the veins. The disorder has been termed " intumescence injury" by the American workers who first recorded it, and it is not unlike "oedema" which has been observed under conditions of low light and high humidity in glasshouses, except that oedema is reported to give larger pustules (4-10mm. diam.) and that disorder appears on the <u>lower</u> surface of the leaf. It was obviously necessary to find the cause of this disorder before we could proceed further with work on tomato.

It was suspected that light quality had an influence on the production of intumescence injury and so we grew plants under 'warm-white' fluorescent lamps (our standard artificial light source) alone, and with additional light from incandescent, far-red, and ultra-violet lamps, all at high humidity. Although the plants under added incandescent and far-red lamps were taller, with thinner stems and smaller leaves, they all developed intumescence injury. The disorder was prevented by placing the additional UV lamps directly above the leaf canopy, below the perspex ceiling which separates the rest of the lamps from the plant growing space. The leaves produced under this regime were also larger and flatter than those under the standard light source alone.

Finally, plants were grown under "warm-white" fluorescent lamps along or with additional UV lamps placed both directly above the leaf canopy and behind the perspex ceiling, and with additional blue fluorescent lamps, all at high humidity. We were able to show that the perspex ceiling absorbed UV light, and when deprived of this at high humidity, tomato plants developed intumescence injury. Additional blue light produced shorter, thicker-stemmed plants with abundant side-shoots but intumescence injury was most severe in this treatment (see Table I)

Table I. the effects of light quality on the growth and development of tomato at high humidity (0.1 kPa vapour pressure deficit) after four weeks of treatment

	Light source		
	"Warm-white"	"Warm-white" + "Blue"	"Warm-white" + "UVA"
Plant height (cm)	81.0	70.6	77.4
Stem dry wt. (g)	2.59	3.10	2.83
Wt/unit length stem (mg/cm)	32.0	43.9	36.6
No. of axillary shoots	2	4	2
Axillary dry wt. (g)	0.84	1.89	1.21
Intumescence score	1	12	0
Calcium deficiency score	21	29	6

The results demonstrate that, in addition to the loss of light and higher humidities produced under different claddings used for energy saving, it is important to ensure that the claddings do not also absorb UV as this could produce intumescence injury in tomato. There is evidence that polycarbonate and certain film plastics can absorb the UV wavelengths concerned (i.e. c. 350 nm).

Poinsettia

We had some initial problems with leaf senescence that were apparently related to the nutritional status of the original cuttings. These have been resolved and we have now decided to maintain our own stockplants so that we can obtain material for experiments at any time of year. Poinsettia, 'Annette Hegg' ('Diva') were grown unpinched in four constant humidities (65, 83, 91 and 96% r.h., 0.8, 0.4, 0.2 and 0.1 kPa vapour pressure deficit). Vegetative plants tended to produce larger leaves at high humidity but when plants which had been induced to flower were introduced into the cabinets, leaf size and shape were unaffected by humidity treatment, whereas the area of red bracts decreased with increasing humidity from 0.8 to 0.1 kPa vpd (Table II). Some bracts were also misshapen at the highest humidity. Above 0.2 kPa (c. 90% r.h.), latex exuded from blisters (approx. 5mm diam.) which formed on the upper parts of the stem and, above 0.4 kPa (c. 83% r.h.), drops of latex formed on the mid-veins and petioles of the red bracts and around the bases of the flower parts (cyathia). Wherever latex exuded, it eventually hardened and formed a grey/black "crud". Discussions with growers revealed that these symptoms are observed in commercial production and can lead to down-grading of the pot plants. The symptoms would appear to be caused by humidities of 83% r.h. or higher.

Table II. The effects of humidity on the total area of leaves and bracts per plant on poinsettia 'Diva'

Vapour pressure deficit (kPa)	0.8	0.4	0.2	0.1
Relative humidity (%)	65	83	91	96
green leaves	475	430	487	452
red bracts	312	291	214	235

Transpiration

In tomato, high humidity appears to exert its effects mainly by reducing transpiration, which in turn, affects the transport of nutrients, especially calcium. We have also turned our attention, therefore, to evaluating methods of assessing transpiration. At Littlehampton, we have used weighing methods and also simple evaporimeters such as the Piche. We have used the Piche evaporimeter to measure evaporation at different humidities in controlled environment cabinets and in M Block, Efford. Rates of evaporation correlated well with humidity and the Piche may provide growers with a simple means of assessing water uptake (Table III). Alternatives under consideration are the development of computer-based models of the effects of solar radiation and humidity on transpiration and systems of measuring water uptake by plants and by crops.

Table III. Evaporation from Piche evaporimeters in M Block, Efford.

A. Volume evaporated (ml) per 24h (12.2.88 to 21.2.88)

DAY HUMIDITY	LOW (0.8)		HIGH (0.1)	
NIGHT HUMIDITY	LOW (0.8)	HIGH (0.1)	LOW (0.8)	HIGH (0.1)
evaporation (ml)	1.30	0.75	0.82	0.37

B. Hourly rates of evaporation (ml h^{-1})

	DAY		NIGHT	
	LOW (0.8)	HIGH (0.1)	LOW (0.8)	HIGH (0.1)
evaporation (ml h^{-1})	0.067	0.023	0.052	0.016

The data suggest that plants lose three times as much water per hour if the humidity is low (65% rh; 0.8 kPa vpd) rather than high (96% rh; 0.1 kPa vpd). Furthermore, the rate of water loss at night was 70 to 80% of that by day at that time of year.

Evaporation is also influenced by tissue temperature and we have used a Minolta, infra-red thermometer to check leaf, fruit and evaporimeter temperature at different humidities. Preliminary results showed that the leaf and evaporimeter temperatures were similar under different humidities.

Future programme

Having established the types of disorder we are looking for on tomato, we propose to concentrate our attention on the effects of humidity on calcium uptake and water loss, and the interactions of humidity with light intensity, calcium supply, solution conductivity, air movement, and tissue temperature. An important aspect will be the effects of relatively short exposures to high humidity. We intend to quantify the uptake of water and calcium under different conditions using various methods, including the possible use of radioisotopes of calcium, with the object of producing means of assessing when plants are at risk and of developing means of correcting localised calcium deficiencies.

With poinsettia, we need to establish the physiological basis of the disorders already observed at high humidity (root pressure, for example, might cause exudation) and to characterize fully, the responses to a range of humidities both during the vegetative and reproductive phases. When we have established the critical level of humidity that is involved, the duration of exposure that is required, and whether high humidity is more deleterious by day or by night, we can assess the stages of plant development that are most susceptible. If root pressure is involved in latex exudation, we have already developed methods of quantifying root pressure and could assess the influences of nutrient concentration in the rooting medium and of root temperature. Growers are also keen that we study the effects of abrupt changes in humidity, light, and temperature, either singly or in combination.

We propose to begin work on cucumber plants when similar work begins at Efford EHS in cucumber crops.