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Environmental effects on greenhouse cucumber production

New research from the NSW Department of Primary Industries has revealed that greenhouse climate control strategies may lead to improved cucumber yield and marketability, as well as improved postharvest quality, potentially leading to improved gross profit margins for greenhouse growers.

The bottom line

- Environmental factors within greenhouses—including planting density, temperature, ventilation and humidity—can significantly affect the production and quality of cucumbers.
- Trial results indicate a trend for increased marketable yield as control conditions improve.
- Post-harvest, produce grown in control conditions also retains its quality for longer, comparative to produce grown in environments with fewer control conditions.

Environmental effects on greenhouse cucumber production

Experiments conducted by NSW Department of Primary Industries' researchers Dr Sophie Parks and Dr Jenny Ekman have demonstrated that growing cucumbers under controlled greenhouse conditions can increase marketable yields and quality, as well as improve post-harvest storage.

The three-year project, funded through the National Vegetable Levy, involved setting up a series of controlled experiments which subjected cucumber seedlings to specific climate and humidity conditions within a greenhouse environment. The cucumbers were then assessed for marketability and yield, as well as being measured for post-harvest quality. While the project is still in progress, initial results show a general trend of increased production and higher marketable yield as greenhouse climate control is improved.

Data analyses are currently being conducted to determine gross margins, however, Dr Parks is optimistic that the results will be positive for growers.

"We're hoping to replicate the work over the next growing season, which will provide us with additional data to work with. But certainly, at this stage, the figures are looking good."

And while the research is currently limited to cucumbers, Dr Parks believes that the outcomes of the project are equally positive for other greenhouse crops grown in Australia.

"While other vegetable trials were not within the scope of this particular research project, we believe that other greenhouse vegetables may have a similar response," she said.

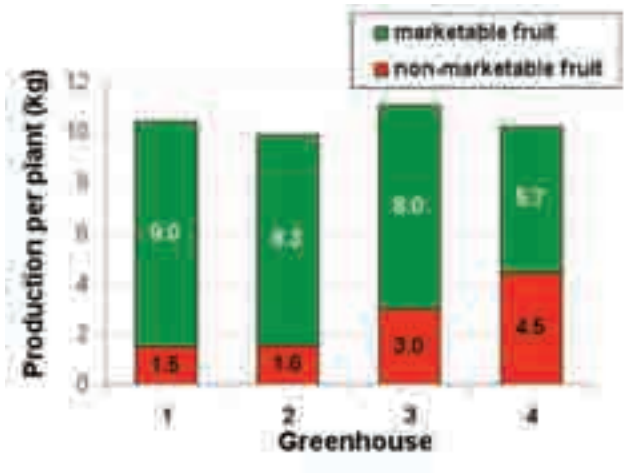


Figure 1. Productivity of cucumber plants grown under optimally controlled conditions (greenhouse 1) ranging to uncontrolled conditions (greenhouse 4).

Climate effects on cucumber production

In July 2008, cucumber seedlings were planted across four poly-houses. In each house, plants were grown hydroponically with identical nutrient conditions at three different planting densities: 2, 2.5 or 3 plants per m^2. Each house was configured to provide different environmental conditions. These were:

1. Full control – heating when required, fan-ventilated or evaporatively cooled during the day, misting at low RH, 60-80% relative humidity (RH)
2. Moderate control – heating when required, passive ventilation during the day, ambient RH
3. Minimum control – cold nights, passive ventilation during the day, ambient RH
4. No environmental control – cold nights, minimal ventilation, cold/hot days, high RH

The results indicate a trend to increased marketable yield as control conditions improve. Although total production was similar in the four houses, there were more unmarketable fruit (misshapen, discoloured, diseased etc) in the poorest conditions of house 4. Marketable yields were higher in the greenhouse configured for full environmental control (*Figure 1*).

Table 1. Effect of density on marketable and unmarketable fruit production for each house. Each number represents the production from four plants. Density was replicated twice but the greenhouse climate treatments were not replicated.

House	Fruit quality	Number of fruit per 4 plants		
		2 plants/m^2	*2.5 plants/m^2*	*3 plants/m^2*
1	Marketable	210	170	158
2	Marketable	171	154	162
3	Marketable	153	147	126
4	Marketable	135	105	89
1	*Unmarketable*	*37*	*28*	*33*
2	*Unmarketable*	*36*	*32*	*30*
3	*Unmarketable*	*67*	*76*	*51*
4	*Unmarketable*	*95*	*91*	*96*

"This experiment highlights the advantage of winter heating for improved marketable cucumber production. At this stage the gross margin analysis is incomplete, however, we hope to be able to demonstrate the potential economic advantage of introducing controlled heating," Dr Parks said.

"Also, despite not having the advantage of heating, greenhouse 3 appears to have the production advantage over greenhouse 4, simply through good passive ventilation. Future experiments will evaluate the control strategies in different seasons," she said.

Shining a light on postharvest UV treatments

Cucumbers from the four houses were also used to examine the effects of exposure to UV-C and xenon light on storage quality. UV-C light can kill surface micro-organisms and may also stimulate the defences of the plant – a bit like giving the cucumber a vaccination.

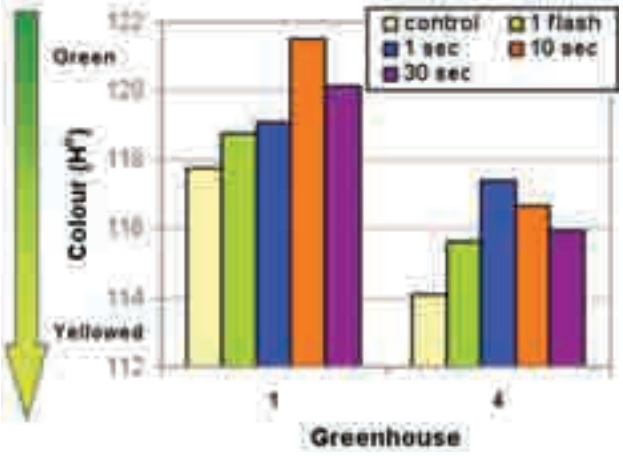
Prior to this experiment, xenon light had not been tested on vegetables before. Even more intense than UV-C, using xenon light reduces the exposure time required. It also gives off almost no heat. Xenon has been shown to enhance vitamin content in mushrooms and may have similar effects on other crops.

Cucumbers were harvested early, mid and late December then exposed to 0, 1 or 5kJ UV-C light or 0, 0.3, 1, 10 or 30 seconds xenon light. They were then stored at 5°C for two weeks, followed by two days at 20°C to simulate normal retail display.

"Unfortunately, none of the treatments reduced rots or prevented chilling injury," said Dr Jenny Ekman. "However, exposure to the lights helped maintain green colour, especially for the late harvested fruit which was more likely to yellow in storage. The greatest benefits were seen for greenhouse 4, for the same reason."

According to Dr Ekman, optimum treatments were 5kJ UV-C light, which took >2 minutes, or 10 seconds exposure to xenon light.

"Xenon lights are currently expensive, which limits the use of this method. However, this could be one technology to watch in the future," she said.



Planting density had only a moderate effect on productivity. However, the highest density seemed to reduce the number of marketable fruit when greenhouse conditions were poor (*Figure 2*).

Post-harvest assessment of cucumbers

The second part of the research involved assessing the impact of greenhouse control on the post-harvest storage and quality of the cucumbers. Dr Jenny Ekman explains that seedless cucumbers are difficult to store for any length of time as they are chilling sensitive and can't be stored below around 10°C. However, at high storage temperatures they quickly soften and rot. The best storage life is therefore achieved by balancing the benefits of cooling against potential damage.

"Our trials investigated whether cucumbers grown in the different environmental conditions had different quality and storage characteristics. Cucumbers from each of the greenhouses were harvested on four separate occasions and taken to the laboratory for storage, followed by post-harvest quality assessment under normal retail conditions."

Table 2. Quality attributes of cucumbers grown in 4 different greenhouses following 12 days storage at 5°C + 2 days at 20°C. Mean values from 4 harvest dates*. Letters indicate the means which are significantly different (p≤0.05).

Greenhouse	Flesh rot *(grade)*	Chilling injury	Colour (H°)	Firmness (N)	Quality *(grade)*
1	0.5 b	1.0 b	118 a	59.4 a	1.8 a
2	0.7 ab	1.3 ab	118 a	55.3 ab	1.1 ab
3	0.9 a	1.3 ab	119 a	55.1 ab	1.0 ab
4	0.9 a	1.5 a	115 b	49.8 b	0.7 b

** Grades are; flesh rot; 0 (none) – 3 (severe), chilling injury; 0 (none) – 3 (severe), H°; high number = greenest, N; high number = firmest, quality; high number = best.*

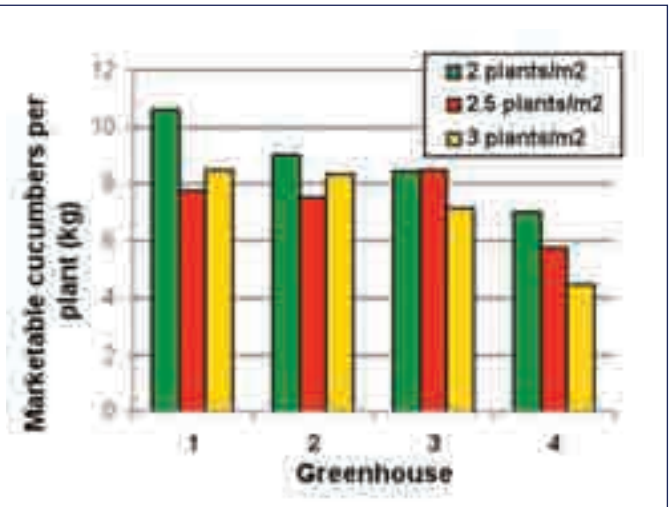


Figure 2. Effect of planting density on the number of marketable fruit grown under optimally controlled conditions (greenhouse 1) ranging to uncontrolled conditions (greenhouse 4).

"We found that although cucumbers from the four houses looked similar at harvest, significant differences developed during storage," Dr Ekman said.

"The cucumbers from the greenhouse with no environmental control were consistently worse after storage than those from the greenhouse with maximum environmental control, with fruit from the other houses generally falling between these two results."

In summary

According to Jenny Ekman, the project results highlight a number of key messages for greenhouse cucumber growers. Firstly, although more work is required to determine critical factors affecting quality, the results demonstrate that investing in climate control can both increase yield and produce a crop with improved storage potential.

"It's important to remember that many of these control measures are not excessively expensive or difficult to implement. We didn't use any technologies that were unrealistically sophisticated or expensive as part of our experiments, so the conditions created in the trials could be implemented by growers in their own greenhouses," she said.

"The other point to make is that growers don't need to go all the way to implementing full environmental control in their greenhouses in order to see some benefits. Obviously, the improvements in quality and yield were most striking in the greenhouse which featured full control, however, simply improving ventilation, or heating through winter will have an impact on the crop."

Further reading

Parks, S. & Ekman, J (2009) *How greenhouse technology and climate affects cucumber production and quality.* To obtain a copy of this paper, contact Jenny Ekman, NSW Department of Primary Industries jenny.ekman@nsw.dpi.gov.au

Images
Cover page: Healthy cucumber crop.
Page three: Xenon hand held test unit.
This page: Dr Sophie Parks examining cucumber plants.
Images courtesy of Scholefield Robinson, Horticultural Services Pty Ltd.

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