BioChambers

PROVIDING GROWTH TO RESEARCH

FREQUENTLY ASKED QUESTIONS

with Dr. Patrick Friesen

FAQ QUESTION #10

How does air movement (fan speed) inside my growth chamber affect the growth of my plants?

Some air movement (air speed or wind speed outside, m s^{-1}) around plants is necessary to develop structural support tissue in stems, branches, and petioles (Grace 1988, Jaffe 1973, Jaffe 1980). Greater air movement reduces the boundary layer of air enveloping plants and their pots. Smaller boundary layers increase convective heat transfer, transpiration (and evaporative cooling), and CO_2 assimilation, whereas larger boundary layers from slower fan speeds conversely reduce these fluxes (Bunce 1988, Downs & Krizek 1997, Friesen 2020, Nobel 1991). In taller plants grouped together, air movement that causes stems to sway and upper leaves to flutter sheds light (PPFD) on the leaves below, changing the whole-plant light environment and potentially stimulating growth (Roden 2003, Tong & Hipps 1996). Too little air movement and mixing can also adversely affect the uniformity of environmental conditions. First, temperature gradients can develop as “hotspots” form where low air movement combines with radiant heat from the lights. Second, CO_2 concentrations can become heterogeneous across the growth space, being higher outside dense plant canopies and drawn down within. Third, humidity can build up within dense plant canopies from transpiration and potentially contribute to pathogen infection. If the vapor pressure deficit is low enough (sufficient humidity) and plants are well watered, a higher fan speed is generally desired for sturdy plants and better temperature, humidity, and CO_2 uniformity.

At some point, increasing air movement makes plants more compact, reducing the size of leaves, shortening stems, branches, and petioles, and ultimately reducing overall growth. Although sunflower (***Helianthus annuus*** L.) growth is reduced by 40% under continuous exposure to 4.02 m s^{-1} compared to 0.45 m s^{-1} air speeds, there are few studies that compare growth reduction effects of continuous exposure to the range of air movements typically found in growth chambers (0.3 to 0.7 m s^{-1}) (Downs & Krizek 1997, Grace 1988, Morse & Evans 1962, Whitehead & Luti 1962). In standard growth chambers and rooms, air movement at 100% fan speed (and associated growth reduction effects) will still likely be less than wind speeds outside, which can vary greatly and currently average around 3.35 m s^{-1} annually across the earth (Morse & Evans 1962, Whitehead & Luti 1962, Zeng et al. 2019). Are your goals to grow plants more phenotypically similar to those growing outside? If so, increasing fan speeds above 85% and incorporating diurnal changes in fan speed (air movement) may better simulate outside conditions. However, plant responses to air movement are species specific and tobacco (***Nicotiana tabacum*** L.) grown under air movement of 0.33 m s^{-1} was found to be phenotypically similar to field grown plants (Raper & Downs, 1976). In BioChambers equipment, the default fan speed is 85% to ensure sturdy plants and uniform conditions, and here the goal is to achieve air movement of at least 0.3 m s^{-1} (Downs & Krizek 1997, Morse & Evans 1962).

The direction of air movement inside growth chambers is a consideration when purchasing new equipment and can affect environmental uniformity and plant growth. In tall plant chambers and rooms (open spaces), airflow is generally upward

from the floor or downward from the ceiling for best mixing and environmental uniformity. In chambers with tiers of shelving, air movement comes horizontally from the sidewalls through a plenum to ensure good mixing and environmental uniformity of each shelf (Figure 1). Upward airflow in tall plant chambers can potentially exacerbate drying of small pots and root tips if pots with several drainage holes are placed directly on the chamber floor, for example, trays of *Arabidopsis*. To prevent this, potted plants can be placed in additional drainage-free trays. Additional factors that buffer against these drying effects are bigger pot sizes and growth media with high water holding capacities. In tiered growth chambers and rooms, a gradient of air movement can develop across the depth of shelves. Here it is especially good practice to rotate your plants if possible to ensure uniform rates of soil drying and plant temperatures. Regardless of the direction of airflow, the number and size of plants adjacent to the source of air movement may alter the air speed and its uniformity across the growth area; it is normally best practice to leave an even amount of space between plants if possible (Figure 1).

Airflow in tissue culture chambers and rooms is upward from the shelves to reduce condensation on the interior of petri plate lids (Figure 1). Darker pigments from the agar mixture and greening plant tissues preferentially absorb radiation from the lights and warm up (Fujiwara and Kozai, 1995). The water from the warm agar mixture evaporates and condenses on the petri plate lids if cooling air movement is downwards or even horizontal. Upward airflow from beneath actively cools the bottom of the petri plates, forcing the water to stay in the agar mixture, reducing condensation on the lids.

A hot-wire anemometer is a good choice for measuring air movement inside growth chambers and rooms, and these are most often directional sensors. Here it is best to select a device that is accurate at the lower air speeds (<1 m s^{-1}) commonly found in plant growth chambers and can be read/logged with the chamber doors shut if possible (Downs & Krizek 1997). Downs & Krizek (1997) recommend a minimum of 5 measurements in the airflow direction across your growth area for a good estimation of average air movement.

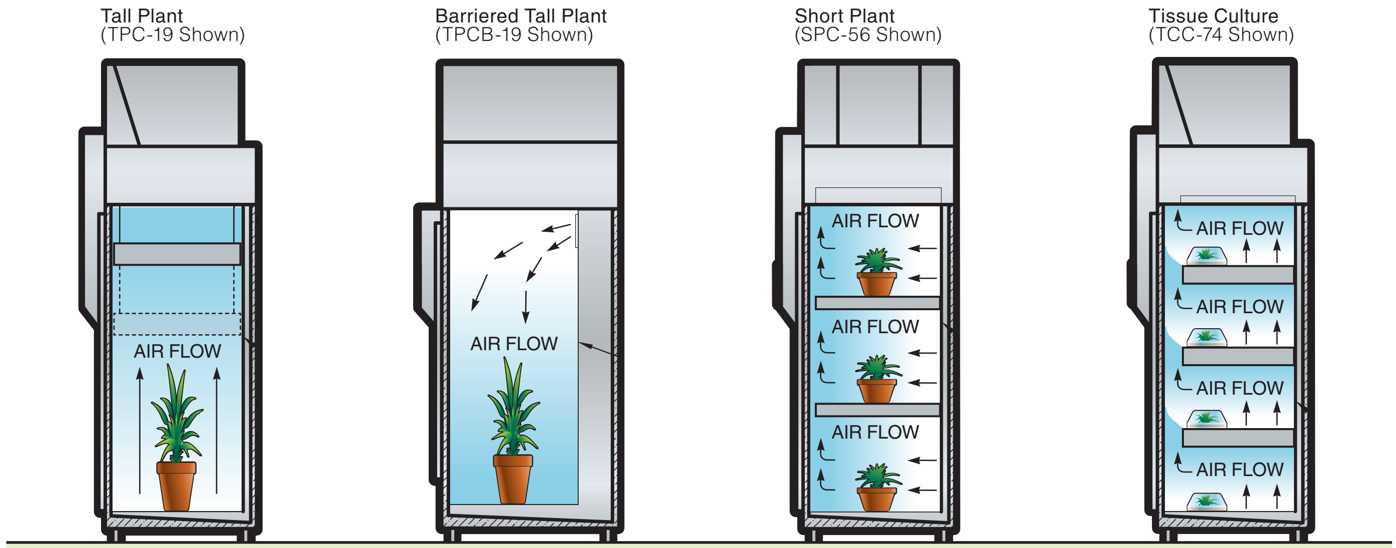

FIGURE 1
Examples of how air flows for different product series. Direction of airflow (air movement) indicated by arrows.

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