Root Performance … Doing More, with Less©

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Starting with a good quality substrate that promotes a good level of porosity is the first step, followed by choosing the right container design that will promote air pruning of the lateral root system. With the right container design in combination with quality substrate, air porosity will develop a strong root system providing increased uptake of water and nutrients resulting in faster growth, better caliper, improved drought tolerance, and high seedling quality. This is the key to keep good customers returning and having them pay the higher value for your seedlings. "Root performance," is the objective for managing for what you do not see, enabling you as owner, grower, manager, or propagator to produce your crops "with less" input but receive "more output".

Root system health is dependent on a good balanced level of oxygen and air porosity. The necessity of O_2 is required to deliver the needed nutrient balance to the surface of the root tissue. Too much water in your medium over a given time can create anaerobic conditions in your containers creating off-gases that are unhealthy for O_2 production and fine root system development. Uptake of nutrients is dependent on a healthy root system tissue, rooting environment, and continual production/branching of a lateral root system (unobstructed). Ideally, you want to increase your root-to-soil surface area as quickly as possible in the early stages of plant development, whether you are starting from seed, cuttings, or tissue culture (look at lateral root growth as your total catch basin, like an umbrella effect). To achieve this goal, container design and media quality are required at the start of your propagation.

It's been proven in scientific studies that short lateral roots (less weight) have a higher level of hydraulic conductivity compared to longer vertical (heavier weight) roots. To achieve roots of this nature, container design must not have a "barrier or wall" or vertically positioned obstructions which deflect roots downward (hopefully not upward) from their natural horizontal position. This is why the Jiffy pellet system is called an "Open Wall Propagation System" (Fig. 1), especially when combined with the Jiffy Air Tray System. The netting/mesh surrounding the pellet allows the medium to be compartmentalized and at the same time, allows roots to develop a natural lateral formation and prevents an artificial water table from developing (parabolic water curve — ability of solid vertical walls to create friction slowing drainage of water based on gravitational pull). The Jiffy pellet allows for natural drying to occur unobstructed.

Fig. 1. Jiffy pellet system.

Another key factor determining root performance is physical positioning of the plant at time of initial root growth. Central positioning is very important to start proper root symmetry, from the initial start of lateral root growth (Fig. 2). Root symmetry determines your net radial production area and receiving area for your water/nutrients. Plants typically will produce 5-8 main lateral roots, and you definitely want these to develop symmetrically at the top of the container having natural root form. This is the start of your main growth engine and will determine how the rest of the plants root system will develop. Root symmetry at this stage in combination with container design has a high degree of influence on root quality once the plant is planted to its final growing location (affects future plant stability and stem quality).

Fig. 2. Central positioning of plant at time of initial root growth.

Obtaining crop consistency and uniformity can be successfully accomplished through proper water and nutrient management (Fig. 3). With quality medium, consistent medium volume per cavity and uniform watering, you are on your way. With cell volume consistency, cell or tray weights can be calculated and developed accurately. Tray weights will never lie and will aid when to water/fertilize in crop scheduling. Combine this with root and soil quality, now you are ready to improve growth rate, plant quality and propagation time — “More for Less”. Tray weights allow you to manage air porosity

levels in your substrate and therefore, create the best growing environment for root health (eliminates the guessing).

Fig. 3. Crop consistency and uniformity can be successfully accomplished through proper water and nutrient management.

When developing tray weights, the main weights to determine and record are:

1) Total saturation weight [100% water capacity or moisture content (MC)] — sit tray in water for 10-20 min.
2) Field saturation weight (70-80% water capacity or MC).
3) Wilting weight (depending on species the range is 35-55% MC).
4) Dry weight [oven dry weight (ODW) is not necessary, you want the minimum dry weight (DW) to where fiber damage has not occurred and fiber resiliency still exists — this is around 10% (±5%) MC].

First, you need to know the dry weight of each cell or the dry weight of a tray (Example, Jiffy pellets are delivered to customers at a DW, from here we know that pellets (depending on mix) will absorb on average 5-7 times their dry weight). Knowing the dry weight of a cell or a tray, you can calculate the remaining weights required to manage your fertilization/watering regime. Tray weights help eliminate fear from growing, tray weights will allow you to train the inexperienced and experienced propagators equally, minimizing the extremes of mortality and aiding in IPM. Healthy plant propagation becomes more in control for the propagator and owner. Knowing the weight balance provides the incentive to know when to water at a particular growth phase of the plant depending on stage of root growth within the cavity.

Table 1 provides an example of how pellet weight influences percent air content in a Jiffy 30-mm pellet, with various expanded heights. Stay in the green zone (30-15% desired air content) and out of the red zone (35% and 10-5% air content).

Table 1. Effect of expansion on percent air in 30-mm pellet.

Pellet	Dry Dia.	mm	**30**	**30**	**30**	**30**	**30**	**30**
Pellet	Exp. Ht.	mm	53	54	**55**	56	57	58
Pellet	Vol.	cc	40.7	41.4	**42.2**	43.0	43.7	44.5
			Weight in grams					
Desired Air Content (%)	35%	Dry	26.4	26.9	**27.4**	27.9	28.4	28.9
	30%	Normal	**28.5**	**29.0**	**29.5**	**30.1**	**30.6**	**31.1**
	25%	Normal	**30.5**	**31.1**	**31.6**	**32.2**	**32.8**	**33.4**
	20%	Normal	**32.5**	**33.1**	**33.7**	**34.4**	**35.0**	**35.6**
	15%	Normal	**34.6**	**35.2**	**35.9**	**36.5**	**37.2**	**37.8**
	10%	Wet	36.6	37.3	**38.0**	38.7	39.3	40.0
	5%	Wet	38.6	39.3	**40.1**	40.8	41.5	42.3

For every pass of a watering boom or every second of watering from a stationary nozzle, a certain amount of weight is added. This weight can be calculated to accurately determine how many passes or seconds are required to reach field saturation, and avoid over-watering into the complete saturation zone or low air content. More is not always better and weights help prevent this from happening, eliminating the guess work. If the tools are available, why not use them to your advantage? Yes, weighing trays takes time, but this application allows you to potentially grow more uniform quality plants per unit area ("More" growth with "Less" resources). This action results in increased sales and revenue allowing you to offset your initial labour input of weighing a few trays. By managing air content, watering/fertilizing when needed, plants will respond with a return of increased growth and possibly decreased propagation time (Fig. 4). In the right container system like the Jiffy pellets, combining all the qualities listed above, plants can be accelerated from the propagation area sooner and sold quicker to customers (In a Jiffy pellet or Preforma cell a root plug or cage is not needed to handle/extract the plant from the tray).

Fig. 4. By managing air content, watering/fertilizing when needed, plants will respond with a return of increased growth.