Young Plant Research Center

Plug Adhesion to the Tray

Internal Report for Young Plant Research Center Partners.

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Executive Summary

- As part of our evaluation of propagation media, we designed a system to measure media adhesion to the plastic tray using a force/tension meter. We found differences between growing media, particularly using stabilized media. This measurement could be useful for comparing different media products, for refining tray shape, tray coatings, and media components including polymers.
- There is a maximum amount of media adhesion for an unplanted tray that is probably desirable, which is probably about 150 grams using either push (force) from the bottom of the tray or pull (tension) from the top of the tray. One low-tech test of whether there is too much adhesion for a stabilized medium without plants may simply be to try to pull the medium out with a drywall screw – if the center breaks from the sidewalls before pulling the entire cell away from the plastic tray, it sticks too much or is insufficiently stabilized.
- There is also an optimum range of media adhesion for finished plants to ensure plugs are not displaced during shipping and are also not so tightly stuck to the tray that cuttings are damaged when they are removed for transplanting. A ball park optimum range is probably 200 to 400 grams of tension per cell. One low tech approach that we have not tried would be to relate tension to a drop or upside-down shaking test to see how many cells fall out.
- We have yet to decide whether pull or push tests (or both) are most useful for horticultural practice. The push force test that removes plugs by upward pressure from below the tray is probably best for tests without plants, because lateral pressure is added when the pulling screw is inserted in the medium. Testing tension by clamping onto the plant stem and pulling upward is probably best with plants because it simulates damage on the plant. We could also use the pushing force method for plugs with plants to compare against pulling tension.
- It may be useful to measure how much pulling tension it takes to damage or break shoots for different cultivars, when removing rooted liners from the tray.

Introduction

The amount that the growing medium in a plug or liner cell is adhered to the plastic tray, which we term here “plug adhesion”, is an important factor in media and tray selection.

If a plug easily falls out of the tray during shipping, then plants are more likely to be damaged as they are loose in the tray, additional cost may be necessary because of netting or plastic covering over the tray, transplanting is more time-consuming, and customers are likely to request credits on the shipment.

If plugs adhere too tightly to the tray, then plants can be damaged during transplant from the force required to remove the plant from the tray, and transplanting is more time-consuming.

It is likely that adhesion is affected by

- the growing medium itself, including the amount of swelling of the medium, the particle size (smaller particles lead to greater surface area and increased contact with the plastic), and cohesion of the medium (including stabilized media forms).
- chemical bonding of the medium to the plastic, including coatings of the plastic
- the moisture level of the growing medium (more moist, more adhesion)
- form of the plastic plug tray, including surface area, angle, and protrusions.
- degree of plant rooting, exerting pressure onto the plastic wall

Our goals in this trial were to:

a) Develop a sensor to measure adhesion of plugs or liners to the plastic tray

b) Measure the base line tension required to remove different commercial media from the tray, both with and without rooted cuttings.

Research methods

A chemistry lab stand was mounted onto a ½-inch thick plywood base (A).

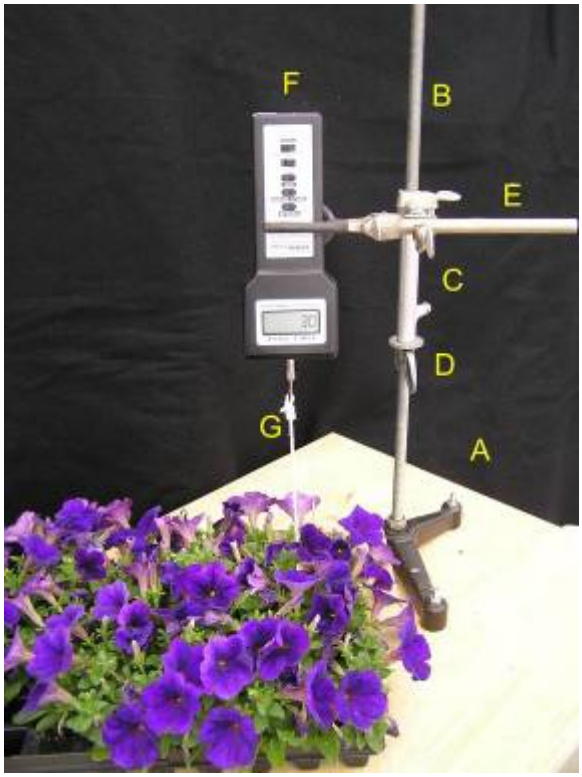
A threaded ½-inch rod (B) was mounted onto the lab stand.

A groove was machined into the ½-inch rod, and a sliding tube (C) was placed over the rod with a set screw to eliminate rotation of the tube.

A wing-nut (D) was used to raise or lower the tube.

A horizontal arm (E) connected the tube to an Extech Model 475040 Force/Tension meter (F, cost $319).

A string was connected to the tension hook on the meter (G), and the base of the string was hooked onto a rooted cutting in a liner tray.



After attaching the based of the string to the stem of a rooted cutting with a clip (shown at right), the tension on the meter was tared (set to zero).

The plastic tray was held in place on the plywood base by an L-shaped lip that fitted over the corner of the tray and was tightened with two screws (right).

By raising the tube up the rod using the wing nut as shown in the right photo, the tension increased on the meter.

The tension meter was set to record the peak tension require to pop the plug out of the tray.

Two trials were run with Calibrachoa 'Superbells Red', sourced from TicoPlant in Costa Rica. Unrooted cuttings were stuck into each growing medium. Loose media were placed in Blackmore size-105 trays, and all stabilized media were size-105 except Oasis (trial 2), which was in size-102 trays.

Table 1 Media types

Stabilized media

1. Stabilized foam
2. Stabilized peat/ perlite/ vermiculite
3. Polymer/peat
4. Polymer/peat
6. Polymer/peat
7. Polymer/peat

Loose media

1. 70% peat + 30% perlite
2. 60% peat + 15% perlite + 25% vermiculite
3. 74% peat + 19% perlite + 7% soil
4. 70% peat + 30% perlite
5. 70% peat + 30% perlite
6. 80% peat + 20% perlite
7. 55-65% peat moss + 45-35% perlite
8. 50% peat moss + 50% perlite

A third trial was then run without plants, where we measured plug adhesion both pulling and pushing the media from the tray.

To pull the plugs, as shown in the photo at right, we screwed a plastic drywall screw halfway into the growing medium. This had the disadvantage that the volume of the screw slightly pushed out the wall of the medium, and therefore probably overestimated the amount of tension required to remove the plug. All stabilized media and one loose medium (Loose #2) were measured.

To measure the force required to push the plugs, the bar accessory was attached to the force/tension meter, and the plug tray was slowly brought down onto the bar (see photo at right).

In trial 1, there were 13 media types, with nine cuttings per tray, and ten replicate trays per media type. In trial 2, Oasis was included along with the 13 media types from trial 1, and there were six replicates each with 16 cuttings per tray. Media included 8 loose-filled trays, and five (trial 1) or six (trial 2) stabilized media (see table below). Stabilized media included Ellepots, Grow-Tech, Preforma, IHT Q-Plugs, IHT Excel Plugs, and Oasis. **Media type codes correspond with those from the Physical Properties report.**

In trial 1, cuttings were stuck on 4/8/2005 and measured 32 days later on 5/10/2005. In trial 2, cuttings were stuck on 4/28/2005 and measured 25 days later on 5/23/2005. Relative humidity set at 75% and kept constant throughout the experiment. Air and bench soil temperature were set at 70-74F for the first 9 days, and were then reduced to 60-65F day/55-60F night. After plants were removed from mist on day 9, they received 150 ppm N from 17-5-17 plus 2 ppm Fe with every watering.

Results

Plants were well-rooted from all treatments at the time that plug adhesion readings were taken, as shown in the photos on the next two pages.

Trial 1. Photos showing representative plugs, 33 days after sticking cuttings (one day after measuring plug adhesion).

Stabilized 2, 3, and 4 (left to right)

Stabilized 5 and 7, and Loose 1

Loose 2, 3, and 4

Loose 5, 6, and 7

Loose 8

Trial 2. Photos showing representative plugs, 25 days after sticking cuttings (the same day when plug adhesion was measured).

Stabilized 1, 2, 3, and 4 (left to right)

Stabilized 5 and 6

Loose 1, 2, 3, and 4

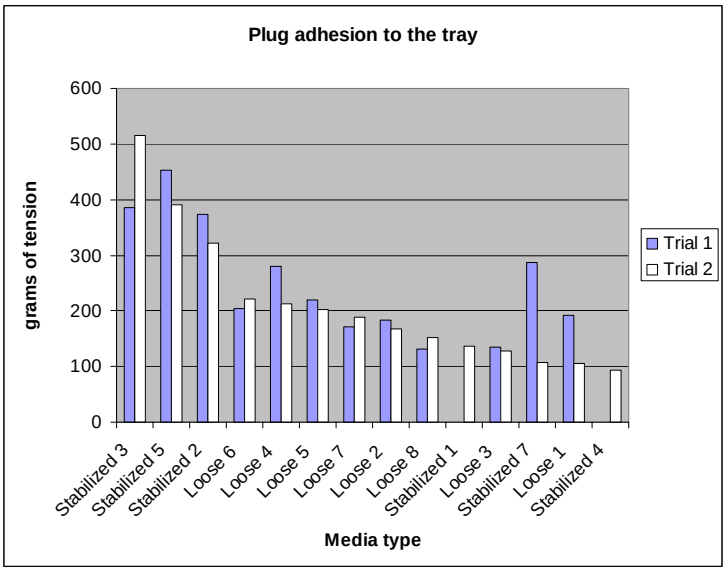
Loose 5, 6, 7, and 8

Results cont.

- Median tension was 203 grams of tension for Trial 1, and 178 grams in Trial 2. The lower tension in Trial 2 was probably because there was less rooting in the second trial (and plug adhesion was measured at 32 days in Trial 1 and only 25 days in Trial 2. For loose media, the median tension was 187 grams in Trial 1 and 172 grams in Trial 2. Stabilized media had

- The three stabilized media that had the highest plug adhesion in Trial 1 also had the highest tension in the second trial.

- Loose media tended to have lower tension than the stabilized media, with the exception of Stabilized 1 (included in the second trial only) and Stabilized 4.



- The table below summarizes results from Trial 3 without media, compared with the results from the first two trials.
- Push force tended to be lower than the pull tension required to remove cells without plants.
- Stabilized 2 had high tension with plants, but moderate tension and force without plants. That indicates that the medium had some combination of swelling of the medium itself over time, plus the force of roots on the sidewalls of cells.
- Stabilized 3 had high tension without plants, and also with plants. This indicates that the medium itself was sticking to the plastic side walls. We noted that when we pulled plugs from both Stabilized 3 and Stabilized 5 out of the cell, in some cases the screw broke out of the medum because the cells were held tightly against the plastic tray.

	push force, no plants (g)	pull tension no plants (g)	Pull tension with plants (g, average of trials 1&2)
Stabilized 2	54	97	347
Loose 2	34	104	175
Stabilized 3	272	272	451
Stabilized 5	56	110	423
Stabilized 4	35	83	145
Stabilized 1	66	91	137
Stabilized 7	28	47	197