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Do plant growth regulator dip solutions "wear out" with repeated use?

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Each year many new lily hybrid cultivars are introduced to the market, mainly for use as cut flowers, and long stem length is an obvious characteristic for cut flowers. These cultivars, when grown as pot plants, require effective height control methods to keep the plant in aesthetic proportion to the container. Moreover, shorter plants are easy to handle and require less volume during transportation which makes them more economical to ship. The industry-preferred height of a lily in a 6" diameter pot is ca. 22" including the pot.

Height control in lilies is mainly done using chemical plant growth regulators (PGRs). Foliar sprays, soil drenches, and pre-plant bulb dips are all common methods of PGR application and each has pros and cons. For example, foliar sprays have the advantage of being labor and material efficient, but sometimes lack effectiveness on oriental hybrids, which tend to "spike up" before a foliage canopy capable of intercepting the spray is developed. Drenches can be highly effective, but not with cultivars that are slow-rooting (the plant can't absorb the drench if no roots are present) and are affected by adsorption onto, for example, pine bark.

Pre-plant growth regulator bulb dips are an alternative to spray and drench applications, and have proven effective in the industry for controlling hybrid lily height. The advantages of pre-plant bulb dips over other methods of PGR application are early plant height control, correct dosage, and (potentially) cost, time, and labor savings. Disadvantages are knowledge of the strength of the dip solution over time (after repeated dips), response variation throughout the year and disposal of the dip solution. Unexplained variation in dip effectiveness might be due to the bulb itself, and include factors such as size, "tight" vs. "loose" scales, and scale moisture content, which undoubtedly decreases during cold (frozen) storage. Non-bulb variables could include the dip solution temperature, presence of peat moss of soil particles in the dip solution, water pH and chemistry, etc.

As far as the dip solution is concerned, it is important to know whether the concentration or effectiveness of the solution changes with time as more bulbs are dipped into it. There is a powerful economic reason as well. Dip solution concentrations tend to be greater than those used for spray or drench applications. Therefore, the cost per bulb is directly related to the number of bulbs that can be effectively treated, hence the number of "repeated dippings".

It is also possible that cultural practices, such as washing the bulbs prior to dipping (to re-hydrate them and presumably improve uniformity), might alter the amount of PGR absorbed. Washed bulbs may not absorb as much PGR as unwashed bulbs. On the other hand, substrate particles on unwashed bulbs may adsorb some PGR that would otherwise be absorbed by the bulbs. Summarizing, all of these factors could influence the efficacy and repeatability of PGR bulb dips. A better understanding of these factors would help to improve industry utilization of this technique, and this research was conducted to address these questions.

Objectives

We conducted experiments based on two objectives: 1) to determine if bulb hydration before dipping changes the amount of PGR (liquid) absorbed, and 2) to determine if PGR dip solutions become less effective as the number of bulbs treated increases.

What we did

In these experiments, we used precooled bulbs (14/16 cm) of the LA hybrid lily 'Fangio'. Bulbs were either used straight from the case (with removal of most of the adhering peat moss used for packing, these were the "unwashed" bulbs), or were liberally rinsed (ca. 1 minute) with tap water to remove almost all of the adhering peat moss ("washed" bulbs). In the first experiment, fifteen sets of 6 washed or unwashed bulbs were dipped for 1 minute into 2 liters (about 2.1 quarts) of PGR solution (200 ppm Bonzi or 2.5 ppm Sumagic. After dipping, bulbs were allowed to drain before planting. All bulbs were weighed before and after dipping to determine the amount of liquid absorbed during the growth regulator dip. The bulbs were grown in 6" diameter pots using Metro Mix 360 in Cornell University greenhouses according to standard cultural practices.

In a second experiment, we increased the number of bulbs dipped into the PGR solution in order to further determine the longevity of dip solution over time. Twenty-four sets of 6 washed or unwashed bulbs (144 bulbs each) were sequentially dipped into 2.5 L (about 2.6 quarts) of 100 ppm Bonzi or 2.5 ppm Sumagic. Since height control in the first experiment was excessive, we reduced the concentration of Bonzi to provide a more rigorous test of the hypothesis (a less concentrated solution presumably would show greater loss of effectiveness). After dipping, plants were handled and grown as above.

What We Found

PGR liquid uptake in washed vs. unwashed bulbs

We expected that washing bulbs would increase their water content and thereby reduce the amount of liquid absorbed during the PGR dip. The data confirmed this prediction: unwashed bulbs absorbed about 1 ml more liquid (Bonzi or Sumagic) per bulb than did washed bulbs. And, the bulbs that were washed before dipping were somewhat taller than unwashed bulbs. The extent of the reduced height control by bulb washing varied by year and by PGR. Bonzi treated plants had slightly more yellowed lower leaves than Sumagic treated plants.

Effects of repeated dipping on dip solution effectiveness

In these experiments, we dipped approximately 90 or 115, 14/16 cm bulbs into about 2 quarts of PGR solution. In either experiment, plant height was not significantly different among the dip groups, and for both PGRs, the last-dipped bulbs were the same height as the first-dipped bulbs (Table 1 and Figures 1 and 2). Thus, there was no change in height control effectiveness as the Bonzi or Sumagic solutions became increasingly "used", regardless of whether or not bulbs were washed before dipping. The PGR solutions at the end of the dipping were dramatically different: the solution used to dip washed bulbs was quite clean, while the solution used for dipping unwashed bulbs was very dirty. These observations suggest that mineral soil or peat moss residue deposited in the dip solution probably did not absorb a significant amount of PGR since the effectiveness of the dip solution was unchanged even as the solution became quite dirty.

Our findings have an important impact on cost effectiveness of dips, as the more times the solution can be used, the lower the material cost. Using the specific case here, using 2.5 liters of

100 ppm Bonzi to treat 144 bulbs comes out to about $0.06 per bulb (assuming $140 per liter for Bonzi). A similar calculation for uniconazole (assumptions: 2.5 ppm solution, $110/liter [$104/qt] Sumagic) yields a per-bulb cost of $0.009. Obviously, the price competitiveness of a particular PGR depends on the concentration needed to obtain the desired response.

Based on this research, we conclude that growers may dip as many as 210, 14/16 cm bulbs per gallon of Bonzi or Sumagic without loss of solution efficacy.

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Table 1. Plant height at flowering for LA-hybrid lily 'Fangio' bulbs (14/16 cm) that were washed (with tap water for 1 minute) or unwashed, and dipped into Bonzi (200 ppm in Expt. 1 and 100 ppm in Expt. 2) or Sumagic (2.5 ppm both experiments). Dip order refers to individual sets of 6 bulbs, each dipped sequentially into the indicated growth regulator (2 liters in Expt. 1 and 2.5 liters in Expt. 2). For clarity, only 1/3 of the dip order treatments are shown.

		Plant height at flowering (cm)			
		Bonzi		Sumagic	
Bulb treatment	Dip order	Expt. 1	Expt. 2	Expt. 1	Expt. 2
Unwashed	Control	87[y]	114	87	114
	3	48	93	51	75
	6	44	91	54	74
	9	46	96	55	78
	12	51	89	61	74
	15	43	92	56	85
	18	---	94	---	76
	21	---	91	---	81
	24	---	87	---	82
Washed	Control	92	114	92	114
	3	52	94	56	85
	6	50	98	67	91
	9	48	100	62	91
	12	52	96	59	86
	15	51	96	61	89
	18	---	104	---	91
	21	---	104	---	92
	24	---	97	---	90

Figure 1A. Bonzi, unwashed bulbs

Figure 1B. Bonzi, washed bulbs

Figure 1C. Sumagic, unwashed bulbs

Figure 1D. Sumagic, washed bulbs

Fig. 1. Experiment 1. The effects of bulb washing and repeated dips into the same Bonzi or Sumagic solution with LA hybrid 'Fangio.'   Two liters of Bonzi (200 ppm) or Sumagic (2.5 ppm) was used to dip 15 sets of bulbs (6 bulbs/set) repeatedly, one set at a time for 1 minute. Top: Bonzi, bottom, Sumagic. Left: unwashed bulbs; right, washed bulbs. In each panel: Control (no dip), water dip, then PGR dip order 1, 3, 5, 7, 9, 11, 13, 15.

Figure 2A. Bonzi, unwashed bulbs

Figure 2B. Bonzi, washed bulbs

Figure 2C. Sumagic, unwashed bulbs

Figure 2D. Sumagic, washed bulbs

Fig. 2. Experiment 2. The effects of bulb washing and repeated dips into the same Bonzi or Sumagic solution with LA hybrid ‘Fangio.’   2.5 liters of Bonzi (100 ppm) or Sumagic (2.5 ppm) was used to dip 24 sets of bulbs (6 bulbs/set) repeatedly, one set at a time for 1 minute. Top: Bonzi, bottom, Sumagic. Left: unwashed bulbs; right, washed bulbs. In each panel: Control (water dip), then PGR dip order no. 3, 6, 9, 12, 15, 18, 21, 24.