Induction of Bud-Break at a Specific Node in Cut-Flower Rose Production©

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INTRODUCTION

It has been shown that apical dominance inhibits axillary bud break and lateral shoot branching in some plant species due to the effects of auxin (IAA) which is biosynthesized in the shoot apex and polarly transported within the plant (Sachs and Thimann 1967; Kitazawa et al., 2008; Leyser, 2003). In rose it has been shown that axillary buds lower on a stem have a higher degree of inhibition then apical buds (Le Bris et al., 1998). The process by which an axillary bud shifts from its dormant state to an actively growing stem is called bud break.

Methods for induction of bud break are commonly used in floriculture to achieve desired plant shape (e.g., to induce branching in potted plants) and for timing of harvests (e.g., cut flowers). The methods currently used on cut flower roses to achieve a particular bud break date, and consequent harvest date, include pinching, pruning, or bending. Pinching involves the removal of the inflorescence to break apical dominance and release the axillary buds below. Pruning is the removal of a large percentage of existing stem tissue to rejuvenate the canopy or create bud breaks at the axillary bud below the cut. During the 1990s stem bending became a commonly used method for timing flower production in cut flower roses. This method has nearly the same effect on the plant as pruning and pinching, in that the axillary buds on the erect portion of the stem near the bend, is allowed to break. In this horticultural method, the stem that is bent ceases to grow and, even if a flower does grow on this bent material, it is not suitable for sale as the stem length is typically too short and flower quality substandard. The carbohydrate production from the bent shoot is available to this new shoot, typically resulting in a stronger shoot then pruning or pinching induced stems (Kim et al., 2004).

Lieth and Pasian (1991) calculated carbohydrate dynamics in growing rose shoots in relation to photosynthesis and respiration over the weeks that were required for a typical cut flower to go from bud break to harvest. They found that halfway through this growth period a luxuriant amount of carbohydrates were available in the lower portion of the shoot, so assimilate resources were available for export from the shoot. This suggested that adequate carbohydrate resources were available to grow a new shoot on a lower node of the flowering rose stem several days before harvest.

Forcing bud break without the loss of a growing flower stem or to induce early bud break on a growing flowering rose stem has been of considerable interest. The use of plant growth regulators (Ohkawa, 1984) and different methods of mechanical manipulation (Orsi et al., unpublished) to the stem have been tried with limited success. To address this, we developed a method that stimulates axillary breaks through mechanical manipulation of the stem by partially compressing the internode above a specific axillary bud. We call this method the “Partial Crush” (PC) treatment. It induces bud break at the proximal node, which will grow to produce

a flower stem for subsequent harvest without harming the current stem or successive growth. The effect on a rose plant was to generate a specific and timed bud break from 7 to 14 days earlier than stem pruning or flower harvesting (Orsi et al., unpublished). Applying this treatment can potentially increase yields of cut flower roses and reduce time between harvests.

Two main experiments were conducted after it was discovered that early bud break prior to stem harvest could be achieved. This method could potentially have various commercial applications and it was necessary to test whether its use in canopy rejuvenation of stock plants was practical and efficient. This experiment tested the effects of the PC treatment on the major rose (*Rosa*) canes that arose from the bud union in an effort to induce new bottom breaks. Bottom breaks or bud breaks that come from lower, older stem tissue on the rose canopy are important to cut flower rose growers in canopy rejuvenation. Bottom breaks are desirable for rejuvenation of the plant canopy because over time flower yields tend to decrease when they develop from older tissue (Kool, 1996). As of now, the only technique available to induce bottom breaks is to severely prune the plant canopy to break apical dominance and force old, dormant axillary buds to break. This can take a significant amount of time for the buds to break and for production to resume. The development of a new treatment that can induce bud breaks prior to pruning for commercial cut-rose greenhouse application could save growers time and money during canopy rejuvenation periods by guaranteeing axillary bud break before pruning.

Additionally, in an effort to maximize application efficiency of the PC treatment the most effective depth and area of compressed tissue needed to induce bud break was tested. The depth of compression at application to the stem, and the height of area crushed on the stem were measured in order to induce uniform axillary bud break before stem harvest.

MATERIALS AND METHODS

Bottom Break Trial. Thirty plants of *Rosa* 'Korlingo', Kardinal® hybrid tea rose, grafted onto 'Natal Briar' rootstock, were grown in 2-gal pots with UC Mix [1 peat : 1 redwood sawdust : 1 sand (by volume)] amended with slow-release Osmocote® encapsulated fertilizer. Plants were established in the University of California, Davis, Environmental Horticulture Complex greenhouses with temperature set points of 20–24 °C during the day and 15.5–18 °C at night. Plants were irrigated with 1,250 mL of amended half-strength modified Hoagland's irrigation solution (Hoagland and Arnon, 1950).

Plants selected for the experiments had 3 to 4 major canes above the bud union. Plants and axillary buds treated for both experiments were chosen at random among the complete block. All data were analyzed with analysis of variance using GLM procedure of SAS (SAS institute, Cary, North Carolina). Means comparisons were done using Student's t-test at the 0.05 significance level.

For the fall trial on 3 Oct. 2008 and 4 Nov. 2008, among 20 plants within the block, all major canes received either the PC or control (CTRL) treatment. The PC treatments were applied 0.5–1.0 cm above the selected node and crushed to 30%–40% of the stem diameter in a few compressing motions. Control-treated buds were flagged for observation. Bud break was recorded when a small bud started to push through meristem. Flowers were continually harvested during this time and measurements were taken for 6 weeks.

For the spring trial, 20 canes were randomly selected to receive either PC or CTRL treatments. Treatments were applied in the same manner as the previous trial. All treatments were applied on 27 Apr. 2009; however, 10 days after treatment the canopy above the selected bud was removed to release apical dominance. Measurements were recorded for 6 weeks.

PC Depth Trial. Three trials were conducted over an 8-month period to test the needed compression depth to induce uniform forced bud break. During the first trial in winter 2009, four treatments were applied randomly within a planting block of 30 roses grown in the same cultural conditions as the bottom break trials. Treatments include compressing the stem 20% (PC20), 40% (PC40), and 60% (PC60) of the stem caliper. Control treatments were flagged at a particular bud. Ten replicates of each treatment for a total of 40 stems treated were applied on 4 Dec. 2009. Digital calipers were used to measure the stem width before the treatment was applied. The caliper of the stem was recorded, the needed depth to compress the treated stem was calculated, and the stem was compressed slowly to that depth in one smooth motion. The treatments were applied 0.5 to 1.0 cm above the most basipetal five-leaflet leaf on the flower stem. The date of bud break and any general observation of the stem growth were recorded. Stems were harvested when all five sepals on the flower were fully extended. Before the stem was removed, its final stem length (cm) was recorded. All harvest dates occurred between 18 Dec. 2009 to 28 Dec. 2009. The average daily greenhouse temperature from the treatment date to the final harvest date was 18.6 °C with a mean PAR of 319.93 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon.

Trial 2 (Spring 2010) replicated Trial 1 at a different time of year. Treatments were applied on 26 Apr. 2010, with the daily average temperature of 22.5 °C and mean PAR of 1027.4 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon from 26 Apr. to 21 May 2010. Stems were harvested on 14 May 14 and 21 May 2010.

Trial 3 (Summer 2010) also replicated the previous trials with the exception of the time of year having higher ambient light levels and with PC treatments being imposed with standard pliers rather than needlenose pliers. The zone of damage induced by the pliers was 12 mm with the standard pliers compared to 3 mm of the stem receiving the crush with the needlenose pliers. Treatments were applied on 16 June 2010. Average daily temperature was 23.9 °C and mean PAR of 1,464.67 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon from 16 June 2010 to 6 July 2010. Stems were harvested from 28 June to 6 July 2010. All data was analyzed by means of analysis of variance using GLM procedure of SAS (SAS Institute, Cary, North Carolina); means comparison were by Student's t-test at the 0.05 significance level.

RESULTS

Bottom Break. Forced bud break to initiate bottom breaks prior to canopy pruning occurred only on stems that received the PC treatment. The strong influence of apical dominance was evident because none of the untreated buds had bud break until the upper plant canopy was completely removed as witnessed after Day 10 in Trial 2 and from the lack of canopy removal in Trial 1. During Trial 1 no bud break occurred for CTRL stems and 7 of 37 treated buds in the PC treatment resulted in bud break. Of those 7, 3 resulted in blind shoots. The PC treated buds in Trial 2 broke significantly faster than the CTRL treatment, approximately 10 days earlier (Table 1). The CTRL treatment however had the least amount of time from bud

break to harvest of the secondary stem at 33.0 days and was not significantly different from the PC treatment which took on average, 39.4 days (Table 1).

Table 1. Average days to bud break and harvest after partial crush (PC) treatment application for Winter 2009 and Spring 2010 trials.

Trial season	TRT	Number per TRT	Number per TRT with BB	Mean days from treatment to bud break	Mean days from bud break to mature bud harvest
Fall	CTRL	37	0	---- a	NA
Fall	PC	37	7	16.7 ± 5.3 b	NA
Spring	CTRL	10	10	24.3 ± 1.2 a	33.0 ± 2.5 a
Spring	PC	10	9	14.0 ± 2.5 b	39.4 ± 5.4 a

Data are means ± S.E. Mean separations are within fall and spring trials and were determined by student's t-test. ($p<0.05$).
Note: BB = bud break, TRT = treatment.

PC Depth Trial. In Trial 1, no bud break was observed prior to harvest although several of the PC treated stems had swollen buds at that time. During the second trial, axillary buds broke prior to flower harvest in two of the four treatments: two stems in the PC40 and two in PC60 treatments each had a bud break while PC20 and CTRL treatments had zero pre-harvest bud break. The PC treatments at the different depths did not reduce the time from bud break to subsequent mature bud harvest in all trials (Table 2). The PAR levels were higher for this trial compared to the previous winter trial, which had no pre-harvest bud break in any treatments.

DISCUSSION

In all trials, bottom break and depth compression, it was observed that the PC treatment performed better during periods of higher light intensity and temperature. While we were not able to determine whether temperature or light was the primary cause of forced bud break, it was observed that these cultural conditions played an important role in early bud break.

The lack of efficacy of the PC treatment during the first PC Depth Trial was unusual since all other trials (data not shown) showed significant effectiveness at inducing bud break. It is possible that light is not the only factor that inhibits early bud break as was seen when the area of tissue was compressed from 3-mm-high-light intensity (Trial 2) to 12-mm-high-light intensity (Trial 3) which increased preharvest bud break (Table 2). With an increase in PAR, temperature, and compressed stem area, an increase in preharvest bud break was observed. A replication of this trial at low PAR/high temperature and high PAR/low temperature with standard pliers would allow us to identify whether the causal factors are PAR, temperature, or area compressed or their interaction.

Since cytokinins encourage cell division and have been found to be translocated acropetally within the plant (Sachs and Thimann, 1967) we suspect that disruption in translocation of the growth substances due to the partial compression of the rose stem reduces inhibitory effects of IAA on axillary buds below the compression

Table 2. Average days to bud break, and subsequent harvest after PC treatment at various depths, plier widths, and seasons.

Treatment	Time of year	Plier width (mm)	Number with BB before harvest	Days to BB after treatment	Mean days from bud break to mature bud harvest
CTRL-T1	Winter	3	0	44.2 ± 8.4 a	N/A
PC20-T1	Winter	3	0	41.2 ± 7.0 a	N/A
PC40-T1	Winter	3	0	38.5 ± 5.8 a	N/A
PC60-T1	Winter	3	0	39.0 ± 10.1 a	N/A
CTRL-T2	Spring	3	0	24.1 ± 1.1 a	38.0 ± 1.3 b
PC20-T2	Spring	3	0	22.1 ± 0.4 a	41.4 ± 1.2 ab
PC40-T2	Spring	3	2	21.5 ± 1.5 a	45.0 ± 3.4 a
PC60-T2	Spring	3	2	22.8 ± 2.6 a	43.8 ± 1.7 a
CTRL-T3	Spring	12	0	17.1 ± 1.3 a	37.4 ± 2.1 b
PC20-T3	Spring	12	2	14.8 ± 4.0 ab	52.8 ± 4.8 a
PC40-T3	Spring	12	1	16.7 ± 2.3 a	42.1 ± 4.1 ab
PC60-T3	Spring	12	5	10.1 ± 1.0 b	53.9 ± 7.2 a

Note: CTRL = control; PC20 = partial crush 20%; PC40 = partial crush 40%; PC60 = partial crush 60%; T1 = Trail 1; T2 = Trial 2; T3 = Trial 3; Data are means ± S.E. Mean separations are within trials and determined by student's t-test. ($p<0.05$).

location. Accumulation of cytokinin below/at the wound possibly encourages cell division and bud release. The actual mode of action is currently unknown.

Further research is needed to effectively and uniformly promote bud break and sustain bud growth pre-harvest. At this time the PC treatment does not reduce the time from bud break to harvest. In hard-to-break plants this treatment might be more effective. Exploring the seasonal variation would be an important future line of research as that will have an impact on timing flowers for holiday production. Additionally, plant carrying capacity of PC treatment and its effects on subsequent stem generations needs to be analyzed. Finding the cause of slow bud growth from pre-harvest bud break to stem harvest should be investigated in order to overcome its inhibitory effects and reduce time between production cycles.

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QUESTIONS AND ANSWERS

Anonymous: Can you go back to the last slide that shows how to do the treatment.

Heiner Lieth: You need needle-nose pliers and a strong wrist. Needle-nose vice grips might be the perfect tool to make a more exact crush of the stem. Compress 30%–40% of the stem tissue. Don't pinch the stem so much that it falls over. Give it a good, solid crush. Figure out which axillary bud you want to stimulate to elongate. Crush the stem about 1 cm above that node.

Anonymous: What species of roses did you test this on?

Heiner Lieth: We tested this on *R.* 'Korlingo', Kardinal® hybrid tea rose.

Michael Vietti: After the crushing treatment, did you use any exogenous growth substances like cytokinins?

Heiner Lieth: We did not. So far we've wanted to fully explore this treatment without the use of any other chemicals. Your question brings up an interesting point. Maybe this treatment simply induces a break, but some follow-up treatment is needed to fully realize the effect.

Jim Berganz: Is the length of the stem that's crushed important?

Heiner Lieth: Not sure since we focused on flower stems that already have a terminal, pea-sized flower bud already. It generally doesn't work well on blind shoots, those that never have a terminal flower bud.