Alaska Agricultural and Forestry Experiment Station

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POST-HARVEST HANDLING METHODS FOR ENHANCED COMPETITIVENESS OF FRESH CUT PEONIES

Part 2.

AFES Research Progress Report 49: Effect of Boron and Calcium Sprays on Stem Strength of Peonies

Mingchu Zhang, PhD, agronomist

Robert Van Veldhuisen, research associate

Plate 1. Robert Van Veldhusien spraying a fertilizer treatment on peonies at the Fairbanks Experiment Farm, Agricultural and Forest Experimental Station, University of Alaska Fairbanks.

See also Part 1: AFES Research Progress Report 48: Vase Life Studies. Patricia S. Holloway, PhD, and student interns Ruth Osborne and Makenzie Stamey (2014) and Melissa Pietila and Kathryn Mihalczo (2013).

University of Alaska Fairbanks
School of Natural Resources and Extension
Department of Agriculture and Horticulture
Agricultural and Forestry Experiment Station

RESEARCH REPORT
to:
Alaska Department of Natural Resources
Division of Agriculture
Alaska Specialty Crops Research Initiative

Post-Harvest Handling Methods for Enhanced Competitiveness of Fresh Cut Peonies

University of Alaska Fairbanks

Patricia S. Holloway

Mingchu Zhang

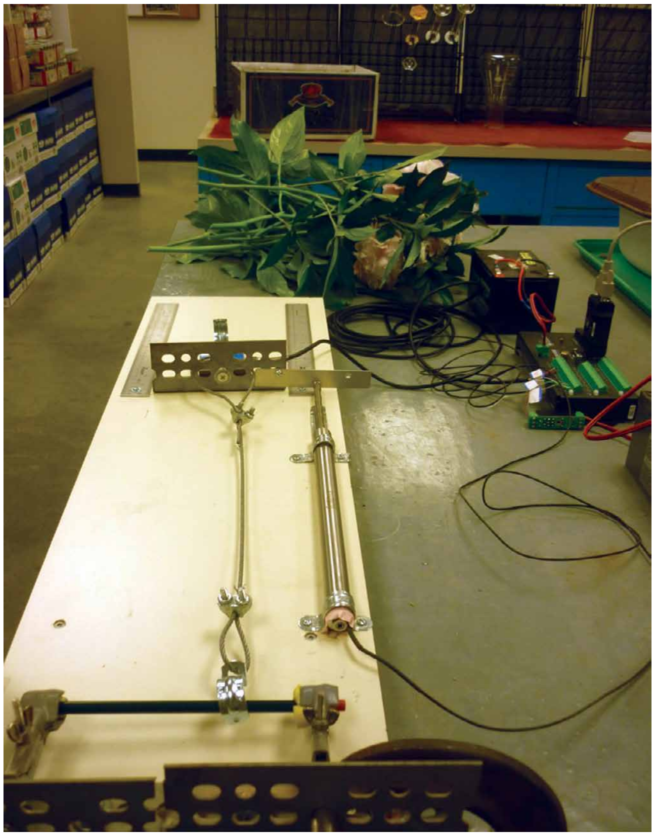


Plate 2. Test apparatus for stem curvature and strength, load cell attached to the bottom plate, LVDT attached on the right, and continuous data logger on the table (far right).

Joint Summary. The University of Alaska Fairbanks in cooperation with Alaska peony growers conducted a series of experiments to establish standards for best quality fresh cut flowers to meet or exceed rigorous international industry requirements. Preliminary research at UAF found that chilling at 34°F for 1 week doubled the vase life of peonies and data from 2013 season corroborates those findings. However, vase life for cut flowers in 2014 decreased significantly and did not improve with chilling. Vase life for 'Sarah Bernhardt' and 'Duchess de Nemours' peonies averaged 6.1 days and 5.9 days, respectively, for the entire treatment period and did not differ from the unchilled control. Because of the unexpected results from 2014, this research did not clearly identify minimum chilling requirements for Alaska peonies. In contrast, cut stems in 2013 showed a linear increase in vase life with chilling (8.2 to 14.2 days for 'Sarah Bernhardt' and 6.9 to 13 days for 'Duchess de Nemours.' Vase life and bud diameter did not differ among early-, mid-, and late-season cutting dates for both cultivars. Cut stems from two commercial farms showed the same short vase life, and there was no statistical difference in vase life among farms. These studies do not corroborate the statement that vase life of Alaska peonies is double the national standard. Environmental factors during spring growth or post-harvest handling differences play a more significant role in defining vase life than simply hours of chilling (deliverables b,c,e).

Vase life for 68 cultivars in 2014 ranged from 4 days to 9 days (mean 6.0 + 1.0 days). In 2013, vase life averaged nearly three days longer, 8.6 + 2.7 days (range 4–14 days). Vase life for 2014 was significantly lower for most cultivars than 2013. In 2013, more than 70 percent of the cultivars showed an average vase life of 7 days or more, while in 2014, only 24 percent reached that standard. The four main classifications of peonies grown at the botanical garden (semi-double, Japanese, bomb and full double) had an average vase life ranging from 5 days to 17 days. One classification had a vase life of less than 7 days for both 2013 and 2014, the Intersectional hybrids (deliverable 1d).

Plants sprayed with Boron (B), calcium (Ca), and potassium (K) showed foliar absorption of B, but not Ca and K. No spray solution improved stem strength or increased stem diameter in 2014. The machine invented to determine bending distance prior to breaking fell short of our goal. Additional work on methods of securing the peony stems in the machine is needed to reduce errors (deliverable 1a)

Part 2. Effect of Boron and Calcium Sprays on Stem Strength of Peonies

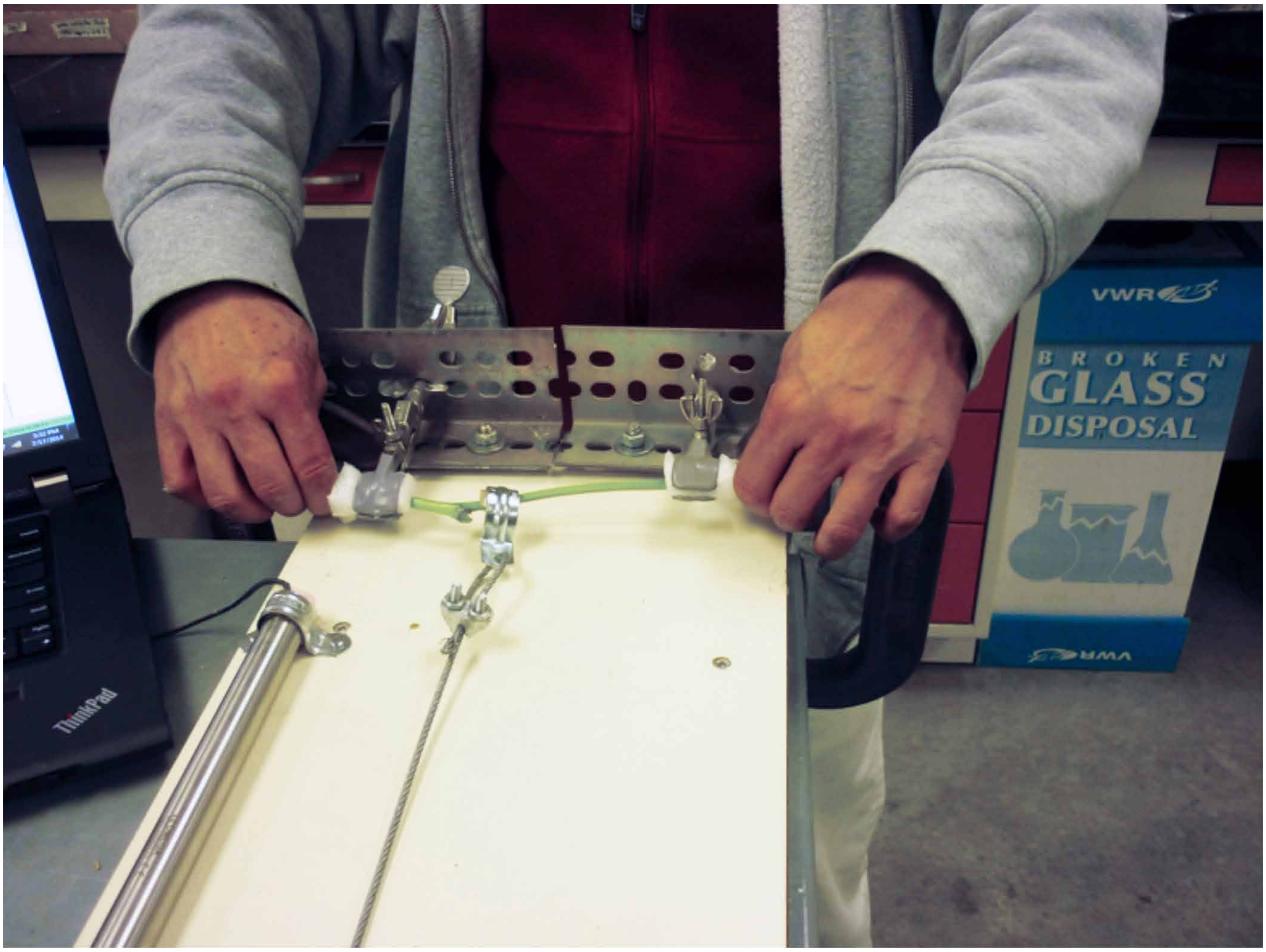
Mingchu Zhang and Robert Van Veldhuizen

Introduction

The peony flower produced in Alaska is large in size. As such, the stem strength of the harvested cut flower can affect the vase life of peony. Research conducted in Chile show that spraying a calcium (10%) and boron based solution to peony cut flowers prior to harvest can increase stem strength (measured as curvature), stem weight, and increase in vase time (Nelson et al., 2012). In China, spraying 4% calcium on herbaceous peony shows an increase in mechanical strength (Li et al., 2012). This enhanced mechanical stem strength probably is gained through an increase of the fraction of cell wall, endogenous calcium, and pectin concentration. To increase Alaska peony competitiveness in the market, it is necessary to know if a calcium based or calcium and boron based spray solution prior to harvest can increase the postharvest quality of the Alaska peony flower.

Herbaceous peonies have a short growing season in Alaska (about 3 months). As such, they have a fast growth rate of the above ground biomass. In addition, the relative humidity in Alaska is low, indicating that a spray solution can be evaporated quickly before it is imbibed by the stems after spraying. Therefore, the designed solution for spraying should have a relatively longer residence time on the plant tissue to allow for more complete imbibition. Also, considering the availability of water in the rural communities, well water should be also taken into consideration. The objectives of the research were to 1) develop an optimal solution for a spray; 2) determine the stem diameter and strength as affected by the spray; and 3) determine the calcium and boron uptake by stems after spraying.

Plate 3. Testing for stem strength and curvature.



Methods and materials

A laboratory experiment was conducted in the Soils Laboratory of SNRE, UAF. A variety of chemicals were evaluated for their suitability as a spray agent. Two criteria were used for evaluation: 1) the solution should contain an organic compound so that it can have a prolonged resident time on tissue surface, and 2) the pH should not be extreme, either acidic or alkaline. After selecting the appropriate chemical compounds, the final spray solutions contained 5% Ca + 0.5% B + 0.1% K and 10% Ca + 0.5% B + 0.1% K. Both solutions had an approximate pH around pH 6.

A field experiment was conducted by spraying the solutions in the AFES research peony field mixed up in well water and in distilled water, respectively. The spray treatments were: 1) 5% Ca + 0.5% B + 0.1% K in distilled water, 2) 5% Ca + 0.5% B + 0.1% K in well water, 3) 10% Ca + 0.5% B + 0.1% K in well water, 4) 10% Ca + 0.5% B + 0.1% K in distilled water, and 5) no spray (control). Each treatment consisted of 32 plants, with the test cultivar being 'Sarah Bernhardt.' Two sprayings were conducted, one at the two weeks prior to hard bud stage (Stage 2), and the other at the hard bud stage (Plate 1, page 1). Six stems were randomly taken for testing at the regular flower cut time. Each test stem was cut right at the first leaf below the flower bud. The stems were measured for their length, diameter, strength, and then dried and ground for laboratory determination of Ca, B, and K uptake. This year, peonies in interior Alaska all suffered from significant bud blast. As such, the results may not truly reflect the impact of the treatment due to irregularity of plant growth.

The instrument for measuring stem curvature and stem strength was developed with the help from faculties in the College of Engineering and Mines, UAF. The measurement apparatus consisted of a load cell and a Linear Variable Differential Transformation (LVDT) instrument connected to a continuous data logger, battery, and holding clamps for the peony stem (Plates 2, 3, 4). The apparatus was calibrated for different masses of the forces that can cause the curvature and eventual breakage of a peony stem.

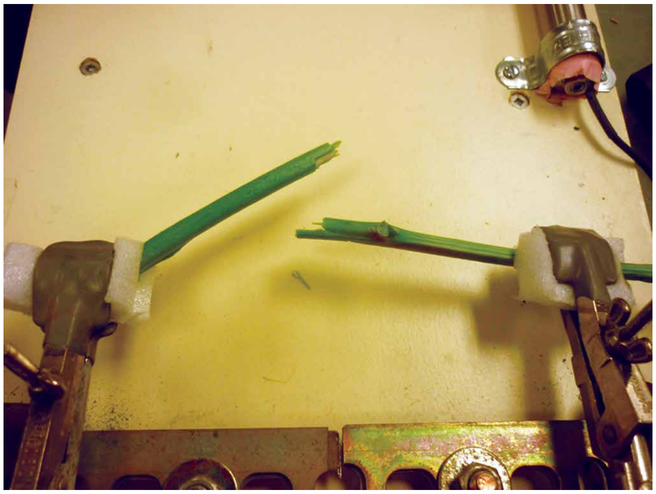


Plate 4. Peony stem broken after a certain level of force was imposed. This force was recorded in the data logger.

Results

The stem diameter tended to be larger in the control treatment (Table 1). The no effect from spraying perhaps was caused by the irregular growth of the plants due to the severe bud blast this year. However, the nutrient

Table 1. Stem length (from bud to first true leaf), and stem diameters from the spray treatments.

Treatment[a]	Stem Length (mm)	Stem diameter (mm)		
		Base	30-cm[b]	Top
1	327.3	5.6	5.5	3.3
2	402.7	7.3	6.5	4.5
3	410.7	7.0	6.6	4.5
4	357.0	6.7	6.5	4.4
5	473.8	7.4	6.6	4.7
Prob. (F test)	0.10	0.05	0.07	0.12
LSD (0.05)	111.0	1.2	0.8	not significant

[a] Treatment: 1) 5% Ca + 0.5% B + 0.1% K in distilled water, 2) 5% Ca + 0.5% B + 0.1% K in well water, 3) 10% Ca + 0.5% B + 0.1% K in well water, 4) 10% Ca + 0.5% B + 0.1% K in distilled water, and 5) no spray (control). b 30 cm below the bud.

Table 2. N, P, K, Ca, and Mg concentration in stem tissue of treated and non-treated stems harvested in July 30, 2014.

Treatment[a]	N%	P%	K%	Ca%	Mg%
1	1.31	0.13	0.28	1.40	0.42
2	1.54	0.15	0.40	1.43	0.36
3	1.32	0.14	0.25	1.40	0.43
4	1.39	0.14	0.29	1.34	0.38
5	1.37	0.15	0.41	1.29	0.35
Prob. (F test)	0.11	0.58	0.02	0.89	0.20
LSD (0.05)	NS	NS	0.11	NS	NS

[a] Treatment: 1) 5% Ca + 0.5% B + 0.1% K in distilled water, 2) 5% Ca + 0.5% B + 0.1% K in well water, 3) 10% Ca + 0.5% B + 0.1% K in well water, 4) 10% Ca + 0.5% B + 0.1% K in distilled water, and 5) no spray (control).

Table 3. Cu, Zn, Mn, Fe, and B concentration in stem tissue of treated and non-treated stems harvested in July 30, 2014.

Treatment[a]	Cu	Zn	Mn	Fe	B
	ppm				
1	4.33	14.17	15.92	58.27	39.15
2	4.70	15.88	12.45	43.55	39.73
3	4.42	15.03	11.60	36.30	40.75
4	4.30	14.48	14.05	58.22	50.83
5	4.40	16.27	11.67	49.25	17.63
Prob. (F test)	0.50	0.60	0.03	0.44	0.0001
LSD (0.05)	NS	NS	2.93	NS	11.05

[a] Treatment: 1) 5% Ca + 0.5% B + 0.1% K in distilled water, 2) 5% Ca + 0.5% B + 0.1% K in well water, 3) 10% Ca + 0.5% B + 0.1% K in well water, 4) 10% Ca + 0.5% B + 0.1% K in distilled water, and 5) no spray (control).

concentration in the stem tissue showed a difference among treatments (Tables 2, 3). There was a marginal difference for potassium (K) concentration in stem tissue, but no trend can be followed (Table 2). For micronutrients, on the other hand, there was a significant difference among the treatment for boron (B), but not for calcium (Ca) (Tables 2, 3). In the spray solutions there was 10% Ca and 0.5% B. Calcium concentrations in stem tissue appeared to be not different among treatments, but the boron concentration was higher for the spray treatments than the control (no spray) (Table 3). The sources of water (well vs. distilled water) for making the solutions were not contributing to B uptake by plants (Table 3). In addition, manganese (Mn) concentration in the tissues was different among treatments (Table 3). Well water was used for Treatment 2 and 3, and distilled water was used for Treatments 1 and 4. Manganese concentration in Treatment 1 and 4 tended to be higher than that in the Treatment 2 and 3. Therefore, it seemed that source of water did have some impact on Mn uptake. Manganese is one of the essential plant nutrients participating in many biological processes in plant (e.g. photosynthesis) (Millaleo et al., 2010). It was not clear why a solution made of distilled water enhanced uptake of Mn in plant tissue.

The newly assembled instrument was calibrated for the stem strength and curvature (or bending distance prior to break) test (Plate 3). The variation of forces and their corresponding voltages were correlated significantly ($r^2 = 0.999$, $p < 0.01$) (Fig. 1). The variation of distances and differential voltage also correlated significantly ($r^2 = 1$, $p < 0.05$) (Fig. 2). These two calibrations set up the basis for

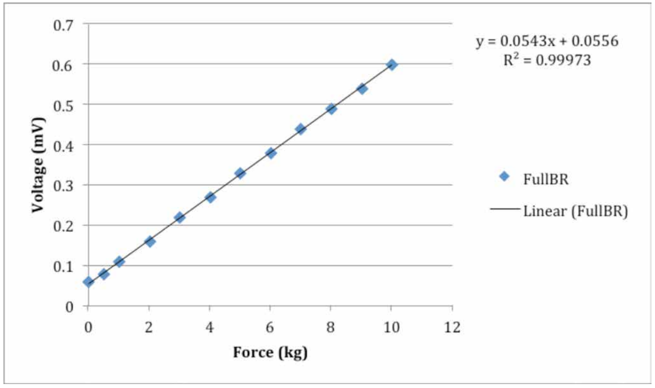


Fig. 1. Calibration of forces for the load cell.

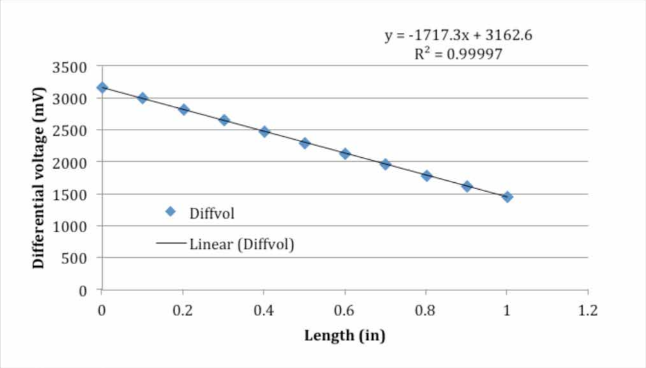


Fig. 2. Calibration of linear variable differential transformation (LVDT).

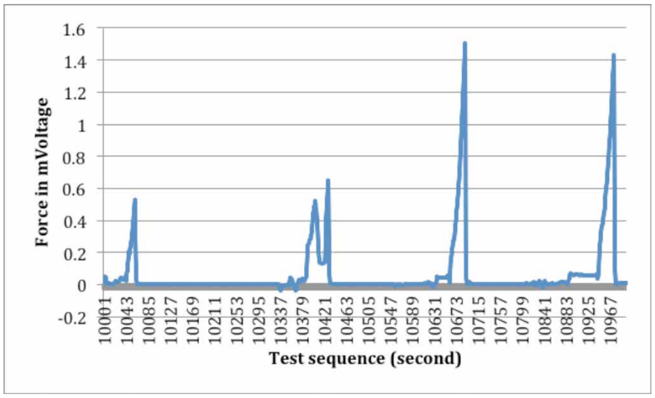


Fig. 3. Example of test for breaking force for peony stems. The higher the peak, the larger the force is required to break the stem.

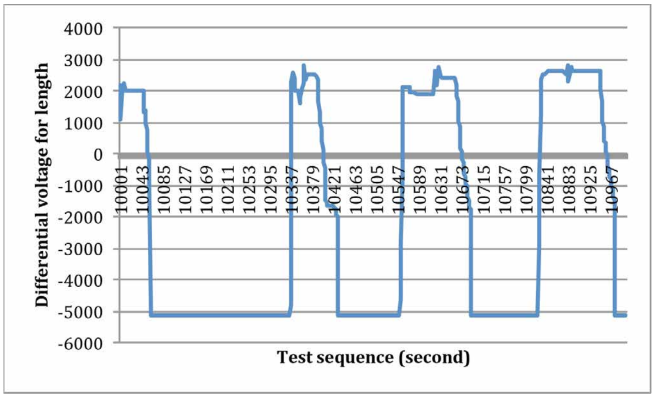


Fig. 4. Example of test for bending distance from which stem was broken. The lower the peak, the more the bending of stem can bear.

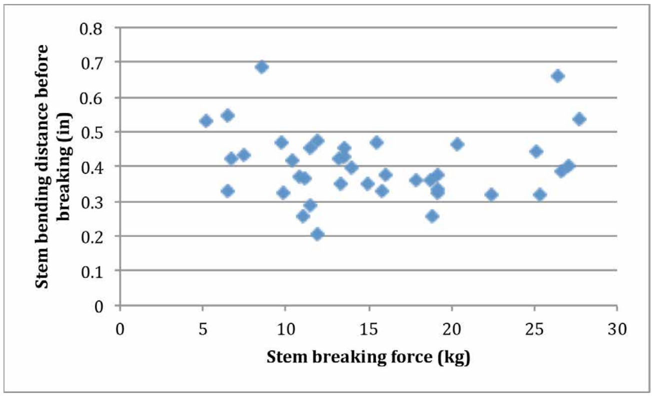


Fig. 5. Relationship between bending forces and bending distances of stems.

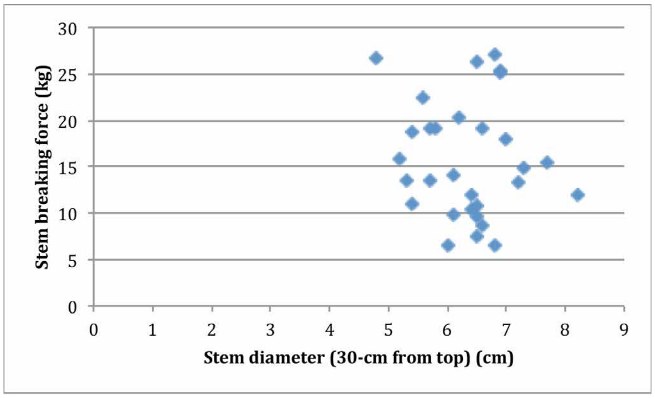


Fig. 6. Relationship between stem breaking forces and stem diameters (30 cm from the top).

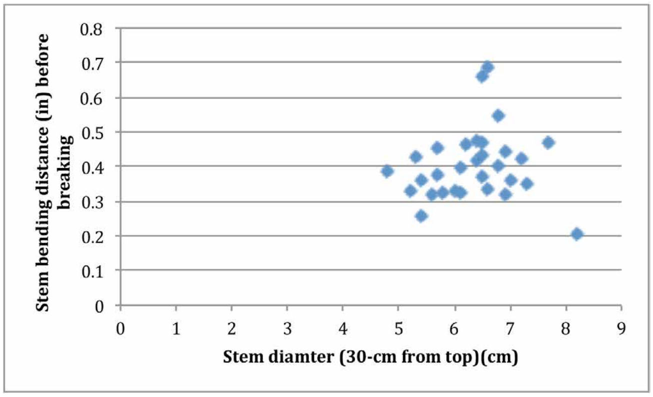


Fig. 7. Relationship between stem bending distances before breaking and stem diameters (30 cm from the top).

determining the force and the bending distance to break peony stems. In the stem strength test, voltage changes were recorded in the data logger connected to the load cell and LVDT instruments, and then calculated for force and distance from the regression equations in Fig. 1 and Fig. 2.

The forces required to break stems did vary from stem to stem (Fig. 3). The higher the peak in the Fig. 3 indicated the larger force that was required to break the stem since there was a positive relation between the voltage and force (Fig. 1). However, the corresponding bending distance prior to breaking appeared to have less variation compared to the force (Fig. 4). There was a negative relation between the distance and voltage, therefore, the shorter the peak the longer the distance prior to breaking. It appeared that there was no relation between the amount of force required to break stems and the bending distance at stem breaking (Fig. 5). Scatter plots showed that the relations between stem diameters and stem breaking force (Fig. 6) and between stem diameter and the distance (Fig. 7) were not obvious.

Weather conditions in the summer of 2014 were not favorable for peony growth. There was a prolonged cool and wet summer during the flower production period in June and July. In addition, there was an unknown variable that caused the abortion of flower buds in many peony plants. All of these can affect the absorption of sprayed solutions by peony plants. As such, peony stem diameters seemed to not positively respond to the spray treatments (Table 1). Also, the stem strength and stem diameter were not correlated. For the stem strength and bending distance determination, the challenge still existed for the device that holds the stem for the determination even after many improvements. Stems in the holding device tended to slide out if a moderate grabbing force was used. On the other hand, the stem ends being held were broken when a strong grabbing force was used. This challenge may not affect the forces to break the stems, but it certainly affected the bending distance prior to stem breaking. Future improvements are needed for a more accurate determination of bending distance.

In conclusion, peony absorbed B but not Ca and K from the solutions sprayed on peony plants prior to flower cut, indicating spraying might be an effective way for applying B to peony plants. The spray solutions didn't affect the stem diameter in 2014, which might be caused by abnormal weather in the summer of 2014 or the unknown variable that caused abortion of peony flowers. Therefore, to verify the impact of the spray solution on stem strength, further evaluation on the impact of sprayed solution on peonies is needed. The newly developed device can detect the forces required to break peony stems, but still fell in short to accurately determine the bending distance prior to stem breaking. Further improvements are needed to make the holding device more accountable to properly hold peony stems for testing.

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About the Agricultural and Forestry Experiment Station

The federal Hatch Act of 1887 authorized establishment of agricultural experiment stations in the U.S. and its territories to provide science-based research information to farmers. There are agricultural experiment stations in each of the 50 states, Puerto Rico, and Guam. All but one are part of the land-grant college system. The Morrill Act established the land-grant colleges in 1862. While the experiment stations perform agricultural research, the land-grant colleges provide education in the science and economics of agriculture.

The Alaska Agricultural Experiment Station was not originally part of the Alaska land-grant college system. In 1898, the station was established in Sitka, also the site of Alaska's first experiment farm. Subsequent branches were opened at Kodiak, Kenai, Rampart, Copper Center, Fairbanks, and Matanuska. The latter two remain as the Fairbanks Experiment Farm and the Matanuska Experiment Farm. The USDA established the Fairbanks experiment station in 1906 on a site that in 1915 provided land for a college. The land transfer and money to establish the Alaska Agricultural College and School of Mines was approved by the U.S. Congress in 1915. Two years later the Alaska Territorial Legislature added funding, and in 1922, when the first building was constructed, the college opened its doors to students. The first student graduated in 1923. In 1931, the experiment station was transferred from federal ownership to the college, and in 1935 the college was renamed the University of Alaska. When campuses were opened at other locations, the Fairbanks campus became the University of Alaska Fairbanks.

Early experiment station researchers developed adapted cultivars of grains, grasses, potatoes, and berries, and introduced many vegetable cultivars appropriate to Alaska. Animal and poultry management was also important. This work continues, as does research in soils and revegetation, forest ecology and management, and rural and economic development. As the state faces new challenges in agriculture and resource management, the Agricultural and Forestry Experiment Station continues to bring state-of-the-art research information to the people of Alaska.

'Duchess de Demours' peony, a double white cultivar that shows a blush of pink.

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Agricultural and Forestry
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University of Alaska Fairbanks
AFES Publications Office
P.O. Box 757200
Fairbanks, AK 99775-7200
fynrpub@uaf.edu • www.uaf.edu/snras
907.474.6923 or 907.474.5042
fax: 907.474.6184

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