Modeling Bud Growth of Peony, *Paeonia lactiflora*

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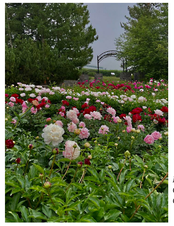
Luke Martin in the Agricultural and Forestry Experiment Station Fairbanks Experiment Farm peony fields.



Peony fields UAF Georgeson Botanical Garden

'Sarah Bernhardt'

Introduction

The peony, *Paeonia lactiflora*, cut flower is a successful domestic and export horticultural product for Alaska. Each plant yields up to two dozen flowers, each with separate bloom times and maturity that must be assessed individually for hand harvesting. A well-trained grower can press the top of the bud and tell by its firmness if it is ready to be harvested. This test is inefficient, requires a lot of training, and isn't always accurate. The cost to growers in time, especially training seasonal workers, and rejected buds, can be substantial.

The purpose of this study was to 1) design a data entry form for field use; 2) Explore two new instruments for testing bud firmness (TF Turoni durometer) and color (Nix Pro 2®); 3) model bud maturity using firmness and bud color; 4) identify if one or more of these factors could be used to accurately predict harvest maturity; and 5) determine if these parameters can be used to predict consumer vase life of peonies.

Methods

Data

Data were collected using two peony cultivars, 'Sarah Bernhardt' and 'Festiva Maxima', at up to three locations, UAF Georgeson Botanical Garden, UAF Fairbanks Experiment Farm and Greenwood Bees and Peonies Farm, Fairbanks. The field experiment for bud maturity began 6/30/22 to 7/4/22. Thirty buds of each cultivar with two each on 15 plants, were tagged at random, and flower buds were monitored for color and firmness daily. Daily averages for all data were analyzed using linear and polynomial regression and r^2 analysis or ANOVA ($P \leq .05$). Data were exported to Graphpad Prizm® Software for analysis.

Data Collection Tool

With assistance from Mr. Chris Benshoof, Lathrop High School, I created a Data Entry sheet using Google Forms and iPhone that allowed me to enter data with one hand while measuring with the other. The Forms

Color Analysis with Nix Pro 2®

The portable colorimeter, Nix Pro 2® (Nix Sensor Ltd, Canada), a professional color matching tool originating in the paint industry was used to collect field measurements of bud color (Fig 1). No known previous use of this device in cut flowers was found, so our experiment would determine if this tool could be used in the cut flower industry as well as its value in predicting peony bud maturity.

The Nix device was placed on the bud as petals matured. The sample (15 mm diameter) was exposed to internal LED light source that eliminated all natural light, and a color sample was recorded on the iPhone. The Nix Ap analyzed the visible color spectrum and translated it into CIELAB three dimensional color space for L* (lightness), a* (red-green color space) and b*(blue-yellow) based on human color perception (International Commission on Illumination). (https://sensing.konicaminolta.asia/what-is-cie-1976-lab-color-space/) With this tool we recorded the change in petal color over time then analyzed CIELAB data by linear regression and the scale representing a* or b* over time.

Fig. 1. Top and sensor view of Nix Pro 2® Colorimeter

Durometer Firmness Analysis

A standard testing tool in the fruit industry is a penetrometer, or fruit firmness tester. As fruit matures, it becomes softer, and this change is recorded when a probe with specific diameter is pressed into the fruit. We found a non-desctructive firmness tester used by the fruit industry, a durometer (TR Turoni, Italy, Fig 2) that records similar firmness measurements in units of "Shores". Our experiment was the first time this tool was used for bud firmness in any flower.

The durometer was calibrated, then pressed against the side of the bud as it matured. Shore measurements were recorded each day until optimum harvest stage was reached.

Fig 2. TR Turoni Durometer

Vase Life

Fifteen peony stems in each of 6 commercial bud maturity stages (Fig.3) were harvested from the UAF Fairbanks Experiment Farm, labeled and stored immediately in the dark at 2 ± 1ºC, 80 - 90% relative humidity for one week. This time in the cooler allowed the flower respiration rate to drop so vase life reached its maximum. After cold storage, bud diameter and color were measured. Stems were placed in jars of tap water (20 ± 2ºC room temperatue, 60 - 70% relative humidity). to simulate a consumer bouquet. Days to full bloom and petal fall were recorded as indication of vase life (Fig 4).

Fig 4. Laboratory vase life study.

Results

Data

The data from the field was collected and deposted onto a Google spread sheet. During a 4 day timeframe full data sets were collected from 33 - 100% of 180 plants each day. Diameter, color, firmness, and pictures of each stem when measured were entered into the spreadsheet.

Data Forms

The data collection using Google Forms worked well in the field and allowed me to only touch the data once in the field by submitting it onto Google Forms and having it drop smoothly onto the Google Sheet with the diameter, color, firmness, and picture of each stem measured. The only problem occured with downloading pictures. Lack of storage capacity prevented the uploading of approximately one third of the pictures.

Color Analysis with Nix Pro 2®

Bd color data collection with Nix Pro 2 colorimeter was fast.and accurate despite the curvature of the bud. The trend in color change showed an increasing level of red pigment as time progressed for 'Sarah Bernhardt' (Fig. 5). Also, the trend in yellow to blue decreased over time (Fig. 6). However linear regression and analysis of the resulting r^2 showed poor fit with the model explaining only 43% of the variability for a* and 37% for b*. Samples on all days showed very high variability among individual buds. Because of the high summer temperatures, there were only four days between the start of the sampling to full bloom. In all instances, the data were inadequate and timing too short to create a useful model of color change. Similar data and response were recorded for

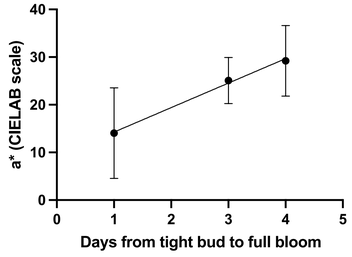


Fig 5. Changes in CIELAB a (red- green scale) in buds growing in the field from tight bud (1.5 scale) to full bloom. Y= 5.138x + 9.127 , r^2 = 0.43*

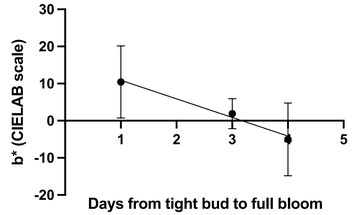


Fig. 6 Changes in CIELAB b (blue-yellow scale) in buds growing in the field from tight bud (1.5 scale) to full bloom. Y= -5.012X + 15.92 , r^2 = 0.37*

Durometer Firmness Analysis

The durometer recordings did not show a consistent trend that could be used in a model of firmness over time. Variability among data points for each was so great, that development of a consistent, repeatable model was not possible. **VARIANCE 20% STATEMENT)**

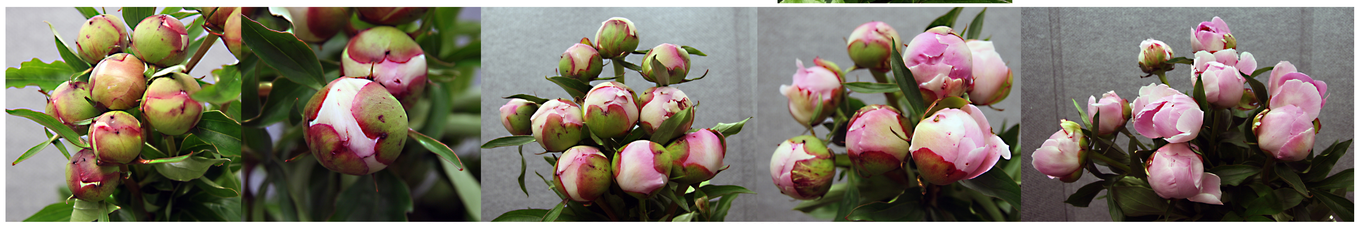


Fig 3 Bud Harvesting stages used in the Vase Life study. left to right - Stage 1.5, 2.0, 2.5, 3.0, 4.0 based on commercial peony scale

Bud Maturity and Vase Life

Color changes with bud maturity were not distinct and statistically different for 'Festiva Maxima', and 'Sarah Bernhardt' and for both CIELAB a* (red- green spectrum) and b* (blue yellow spectrum) (Fig. 6). The pattern of change as the buds matured from a tight bud stage (stage 1.5, Fig 3) to loose bud stage (stage 4 Fig. 3). showed no consistency for the two cultivars and the different bud stages. In all instances, the greatest differences occurred between the 1.5 bud stage where the buds were mostly green to the 2.0 to 4.0 bud stages. However, in part, because of high variability among individual buds in each stage, the CIPLAB a* and b* scales cannot be used to identify bud maturity stages in the two cultivars. Vase life decreased with increasing bud maturity, however, the deviations from the mean decreased as buds approached full bloom (Fig. 7) .

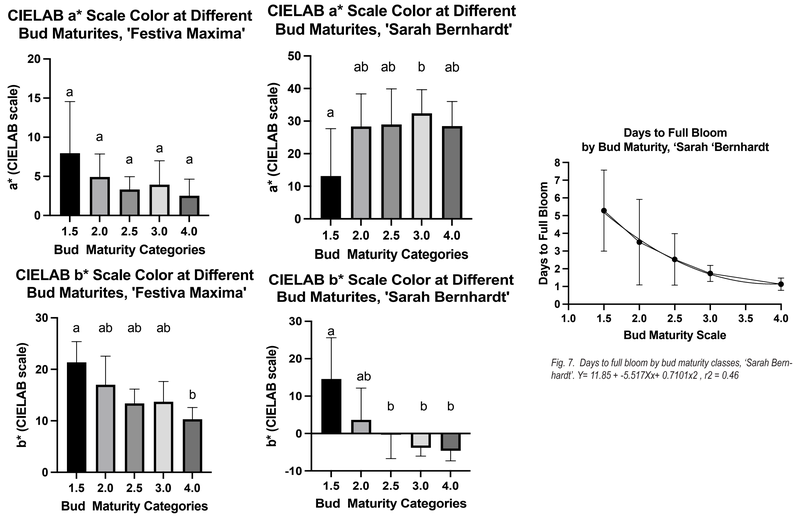


Fig. 6. Differences in CIELAB scale a and b* for 'Sarah Bernhardt'' and 'Festiva Maxima' peony buds at different stages of maturity.*

Fig. 7. Days to full bloom by bud maturity classes, 'Sarah Bernhardt'. Y= 11.85 + -5.517Xx+ 0.7101x2 , r2 = 0.46

Discussion

Although data collection using Google Forms worked well, a two person team, would help with the 180 buds that were measured each day. One small problem with the Google Forms was the time needed upload pictures of the peonies. A link between photos on the spreadsheet and Cloud storage, would allow for more rapid data upload speeds in the field.

The Nix Pro 2® colorimeter shows promise for developing models based on bud color change over time. Changes in a* and b* CIELAB scales may provide a predictable model useful to scientists and growers. Based on this preliminary study, a larger sample size will be necessary for accurate predictions. CIELAB also is a three dimensional record of color. We chose to attempt models eliminating the L* (lightness) variable and concentrating on a* (red - green) and b* (yellow- blue) separately to learn the system and how each component changes with bud maturity. Future attempts might include multivariate modeling, although this level of analysis is not something a grower could perform.

The durometer was difficult to use for bud firmness in part because it was hard to define a specific location for testing on the side of the bud, and the *shore* scale used for fruit was not accurate for peony buds. Also, because of the warm summer, buds opened so fast from hard, green stage to full bloom, it was difficult to record a trend in firmness. They were either hard or not! Modifications to the durometer that include a more accurate "shore" scale for flower buds will be necessary along with a consistent method of measuring.

Only the color analysis was attempted on The Bud Maturity and Vase Life part of this experiment could have a few improvements, but helped to show some good signs of potential color modeling. While this year there was data taken in all 6 of the categories for peony development (1.5, 2.0, 2.5, 3.0, 4.0, 5.0), there wasn't enough data in any specific category to really have a firm r^2 value. If instead there was a focusing on 2.0, 2.5, and the 3.0 categories, having 40 stems in each of those categories could help produce some sizable data sets. Those three categories are also generally what commercial growers use for harvest, so that makes them the most applicable categories to focus on. Vase life studies are difficult to show a definitive "end" date. Some stems wilt, while others show petal abscission and fall. It is quite subjective on the part of the scientist to determine the end point. When the total life of a peony stem in a vase is 7 - 10 days, adding a day or two to the vase life of a single flower can make a huge difference in data analysis and predictions.

Conclusion

The Nix Pro 2® colorimeter and Turoni durometer were used for the first time in attempting to predict bud maturity. The classic method is to press down on each bud and guesstimate the proper firmness by feel. This method is difficult to master and leads to significant grade-out losses in commercial cut flower peonies. The durometer did not prove useful in predicting bud firmness, and will need to be modified and calibrated specifically for flower buds. There are promising signs of relationships between color change and harvest date of peonies, but experiments require significantly more data points to refine the relationships between color and harvest days. This preliminary study revealed many shortcomings in data collection strategies as we became familiar with the new tools. Future studies should include larger data sets and measurements that focus on buds in the 2, 2.5 and 3.0 bud maturity stages.

Acknowledgements

I would like to thank Dr. Patrica Holloway for all her help in designing, organizing, and executing this plan. She was instrumental in the creation of this poster as well as the discoveries of the Nix Pro 2 and the Durometer. My old highschool engineering and math teacher, Mr. Chris Benshoof, was very instrumental in designing the Google Forms application that allowed me to streamline the data collection process. He also helped me with a variance analysis on the Durometer. I would also like to thank Katie DiCristina and Lacey Higham the two lead caretakers of the Botanical Garden. They gave me access to the peony fields in the Georgeson Botanical Garden that was crucial for data collection. And I would like to thank everyone who helped me in any other small way. This project would not have been possible without all this help.