Calcium Sprays on Roses during Greenhouse Production (Experiment in progress): For 24 consecutive weeks, Ca sprays have been applied in two commercial greenhouses in Colombia at 0, 500, 1000 and 1500 ppm Ca using calcium chloride as the source of calcium. The objective of this experiment is to evaluate the effect of calcium sprays on the severity of gray mold and the calcium content in rose tissues. The cultivar used for the study is Orange Crush.

Five commercial shipments have been received in 2019 from WK34, WK40, WK43, WK50 and WK51 and disease severity assessment was made after 3, 5 and 7 days in a humid chamber. Shipments made during WK40 and WK43 were also used for tissue analysis of calcium content. Two tissue analysis strategies have been used to evaluate calcium content in the rose tissue:

1. **ICP** (Inductively Coupled Plasma Spectroscopy): This is the standard technology used for performing tissue analyses. Petal, leaf and stem tissue have been submitted to a USDA-ARS lab, and we are awaiting results.
2. **EDX** (Energy Dispersive X-ray Spectroscopy): This technology allows us to pinpoint specific layers within plant tissues and evaluate whatever element is of interest. In this case, we are measuring calcium in the epidermis as well as in cross sections of petal, leaf (Figure 1) and stem tissue to observe if calcium applications are being effective in getting the calcium inside the tissue.

![Figure 1](image.png)

**Figure 1:** Cross section of a rose leaf using EDX spectroscopy. The rectangles identify the portions of the leaf cross section that are analyzed for calcium concentrations and the graphs on the right display the spectra generated.
Results: Disease severity was analyzed using the Area Under the Disease Progress Curve (AUDPC) to evaluate the whole disease progression across the different days of evaluation. The 1000 ppm Ca was statistically lower than the control treatment (Figure 2); however, no differences were observed amongst the calcium spray rates.

![Figure 2: Disease severity (Area Under the Disease Progress Curve, AUDPC) for the calcium spray treatments.](image)

The EDX analysis did not show any differences in the calcium content within in the leaf and petal tissues for any of calcium spray concentrations. However, the 1500 ppm Ca spray treatment showed a significant increase in the calcium content for stem tissue (Figure 3).

![Figure 3: Calcium content in leaf, petal and stem tissue from different calcium spray treatments obtained using EDX.](image)
Calcium Dips on Roses in the Post-harvest Environment: The effect of post-harvest calcium dips in gray mold severity was evaluated through five commercial shipments for the cultivars Orange Crush (5 shipments) and Freedom (3 shipments). Two different calcium treatments (1000 and 2000 ppm Ca) were compared with a negative control (0 ppm Ca) and a post-harvest commercial hydrogen peroxide product.

Additionally, EDX tissue analysis was done using dip treatments of 0 and 2000 ppm Ca on Freedom and Cayenne roses to evaluate the effectiveness of calcium dips to get the calcium inside the petal tissue. For this purpose, outer (the outer-most layer of petals), middle (the second layer of petals) and inner (the fifth layer of petals) petals (Figure 4) were taken from the roses in each of the treatments.

Results: In the first dip experiments with Orange Crush, disease severity was significantly reduced with 2000 ppm Ca dip treatments in comparison with the commercial hydrogen peroxide product and the 0 ppm Ca control group. (Figure 4).
In the second dip experiment with Freedom and Cayenne, the calcium content in the outer and middle petals was significantly higher for the 2000 ppm Ca dip compared with the control (Figure 5).

These results suggest that the post-harvest Ca dips are more effective than sprays to reduce gray mold severity in roses because the dips are more effective at increasing the calcium content of the targeted tissues. Spray applications primarily target the exterior (outer) petals of a rose, and the calcium is not
translocated to the interior (middle and inner) petals. Dips are very effective at delivering calcium to the outer and middle petals. The middle petals are often the place of development of the first gray mold symptoms in roses (Figure 6). We believe this occurs because the fungicides adequately target the outer petals, while the interior petals are exposed during the last week before harvest, so they do not have adequate protection from the fungicide sprays.

![Figure 6: Gray mold symptoms developing on the middle (interior) petals.](image)

In our previous research, calcium sprays on petunia flowers during bud development were very effective at decreasing gray mold severity and increase calcium content in the flower tissue. Petunias have a single petal (Figure 7), so when the bud is sprayed, calcium is transported throughout that petal. When the flower opens, the petal has improved calcium content and enhanced protection against Botrytis infection.

The morphology of roses is different than petunia, and the calcium sprayed on the outer petals does not improve the calcium content of the interior petals. Thus, spray applications of calcium to roses do not appear to be as effective as dip applications, especially for protecting the interior petals. This research is still in progress, so these results should be viewed as tentative and not final.
Figure 7: Petal arrangement in petunia flower buds. Petunias have a single petal, so calcium sprays applied to closed buds will help to protect the entire flower when the bud opens.