Perishables
Research
Organization

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Date: July 15, 2010

To: Shubham Chandra

From: George Staby

Subject: CA FILMS™ Rose Test Report

Six rose cultivars ('Cherry Brandy', 'Vendela', 'Freedom', 'Engagement', 'Blush' and 'High & Magic'), all at the same cut stage, were harvested on June 10, 2010 in the Quito area of Ecuador at the farm of Agroflora and Queenroses under the direction of their manager, Juan Francisco Viteri, and with the guidance of my Ecuadorian associate, Gabriela Cordova of Conectiflor. As a point of reference, the start of this test was delayed for about three weeks because of problems getting the CA FILMS™ bags and other items into Ecuador via Federal Express and an additional week because of personnel situations at this farm.

The roses were treated normally at farm level in terms of hydration, bunching, and temperature management prior to being packed in one of three box treatments. The box treatments were normal (no vapor barrier and no CA FILMS™ bags), flowers loosely encased in polyethylene as a vapor barrier, and the provided CA FILMS™ bags plus one silica gel sachet per box placed inside the CA FILMS™ bags.

A second box bottom, slightly smaller than the normal box bottom, was used for the CA FILMS™ treatments. Flowers were put into the slightly smaller box bottom, secured by a strap as with all the boxes, and then the slightly smaller box bottom and flowers were slid into the CA FILMS™ bag and sealed with elastic bands. Finally, the smaller bottom box bottom with the flowers, encased in the CA FILMS™ bags, were placed into the normal box bottom and covered with a normal box lid. The two CA FILMS™ membranes per bag were situated in the center-top of the flowers.

Flower temperatures at the time they were placed into the boxes averaged 3.2 C (37-38 F). One bunch (25 stems) of each cultivar (five bunches total) were placed into each box for a total of 150 flowers per box.

Temperature measuring devices (data loggers) were to have been placed into some of the boxes but their whereabouts at the time of packing was unknown. It is speculated that during the long delay in getting the CA FILMS™ bag shipment through Ecuadorian customs resulted in them being misplaced or they were very likely removed if they were not declared on the forms that accompanied the FedEx shipment.

After packing, flowers were transported the same day to Quito Airport and flown that night to Miami on a dedicated flower freighter aircraft. Upon arrival in Miami and after clearing customs and pest inspections, they were held in a cooler until Monday at which time they were transported by refrigerated truck to Sacramento, CA, arriving at about 1:00 PM on Thursday, June 17, 2010. The average flower head temperature of the control flowers upon arrival was 37-39F.

The 18 flower boxes were immediately transferred (25 minute ride) to a research facility at the University of California, Davis (UCDavis) by an air-conditioned vehicle where they were inspected for damage that revealed that none of the boxes and/or CA FILMS™ bags was damaged and only one was inspected. Oxygen and carbon dioxide levels were measured in all boxes and the results recorded. After photos were taken, flowers were placed into a 33-35F cooler to begin their approximate two or three week stay.

Four of the six replicates (12 boxes total) were removed from the 33-35F cooler at UCDavis on June 30, 2010, gas levels measured, and the three test cultivars from each treatment (‘Freedom’, ‘Engagement’ and ‘Vendela’, 36 bunches total) transported to my facilities by air-conditioned vehicle for vase life determinations. The total trip time was about two hours.

Upon arrival of the 36 bunches at my facility, each bunch was opened and inspected, stems recut to 18 inches under water, lower foliage removed, and placed into a 1.0% flower food solution (Floralife Crystal Clear Powder) made with tap water (alkalinity of 85 ppm). The flowers were then placed in a postharvest vase life room that provided 18 hours per day of cool white fluorescent light at 72-74F. Seven stems of each cultivar were used per treatment and replicate for a total of 36 jars, each containing 900 ml of the flower food solution. Flower food solution was replenished when needed.

The other six boxes remained in the cooler, except for the brief time they were removed to measure gas levels on June 30, for an additional week at which time they were removed and pictures taken on July 7, 2010. Vase life determinations and gas level measurements for these flowers were not performed.

The following pictures depict how the flowers and packaging looked at the farm the day of harvest and upon arrival in Sacramento and UCDavis on June 17, 2010 as well as on opening on June 30, 2010 at UCDavis and at my facility.

Control flowers during packing at farm.

Vapor barrier flowers during packing at farm.

Completed vapor barrier flowers at packing.

CA FILMS™ flowers at time of packing, note two box bottoms.

Flowers on truck at time of arrival in Sacramento (purple boxes). This was the last stop for this dedicated flower truck, hence the reason why the test flowers were loaded first.

Flower boxes upon arrival at UCDavis lab.

CA FILMS™ box upon arrival at UCDavis showing membrane locations.

Another picture of a CA FILMS™ box upon arrival at UCDavis showing both box bottoms. Note the plastic through the precooling hole where the bag was secured with elastic bands.

CA FILMS™ bag upon removal from storage on 6/30/2010 showing inner and outer box bottoms.

CA FILMS™ bag upon removal from storage on 6/30/2010 showing inner and outer box bottoms, box lid as well as the area where the bag was closed with elastic bands.

Inspecting ‘Vendela’ roses upon opening bunches for vase life studies on 6/30/2010.

Overview of flowers in vase life room on day one, 7/1/2010.

Oxygen and carbon dioxide levels in the CA FILMS™ and vapor barrier boxes upon arrival (6/17/2010) and after 13 days storage on (6/30/2010) are summarized in the following table. Gas levels in the control boxes were the same as the room air.

Approximate oxygen and carbon dioxide levels in flower boxes at two dates.

Treatment	Box number	Oxygen (%) 6/17/2010	Carbon dioxide (%) 6/17/2010	Oxygen (%) 6/30/2010	Carbon dioxide (%) 6/30/2010
CA FILMS™	1	17.46	1.23	16.29	2.39
	2	11.20	5.64	9.89	6.71
	3	16.81	1.78	18.38	0.74
	4	17.80	1.20	16.62	1.67
	5	12.91	4.12	15.45	2.78
	6	14.71	2.93	13.88	3.90
Average		**15.15**	**2.82**	**15.09**	**3.03**
Vapor barrier	1	18.43	0.26	18.70	0.37
	2	18.54	0.11	18.82	0.49
	3	18.56	0.06	19.08	0.10
	4	18.62	0.15	18.19	0.02
	5	18.67	0.08	18.76	0.28
	6	18.49	0.46	18.65	0.31
Average		**18.55**	**0.19**	**18.70**	**0.26**
Room air		18.76	0.00	19.00	0.00

In addition, the gas analyzer you provided was tested against a laboratory certified gas standard on June 17, 2010 with the following results. The analyzer read 10.21% for a 9.91% oxygen standard and read 6.73% for a 9.49% carbon dioxide standard. Hence, it is hypothesized that both the oxygen and carbon dioxide levels measured by your instrument were somewhat inaccurate but the relative readings should be okay.

In a second attempt to confirm the accuracy of the gas measurements made by your instrument, another gas-measuring instrument from UCDavis was made available to me for the samples taken on June 30, 2010. After attempting to standardize this instrument for over am hour, it was surmised that it did not work properly and therefore could not be used.

I do not have sufficient knowledge of your membranes to comment on their effectiveness in the CA FILMS™ gas measurements noted in the previous table other than the results were somewhat inconsistent, did not change very much over the 13 day storage period, and the oxygen levels were seemingly high.

Data presented in the following table summarizes the percentage of acceptable flowers per bunch of 25 stems upon opening them at the start of the vase life test on June 30,

2010. This subjective analysis attempted to predict how average commercial receivers (wholesalers, bouquet manufactures, Internet flower providers, retailers, etc.) of these flowers would respond to them, namely, would they be completely satisfied, as indicated by a 100% finding, or would some questions be possibly raised if something less than 100% were the case.

Percentage acceptable roses upon removal from storage on June 30, 2010.

Treatment	Rep	'Freedom'	'Vendela'	'Engagement'	Grand mean
Control	1	96	100	100	
"	2	96	100	92	
"	3	84	100	100	
"	4	80	100	100	
Average		**89**	**100**	**99**	**96.0**
CA FILMS™	1	96	100	100	
"	2	96	100	100	
"	3	76	100	100	
"	4	72	100	92	
Average		**85**	**100**	**99**	**94.7**
Vapor Barrier	1	88	100	100	
"	2	88	100	100	
"	3	96	100	100	
"	4	92	100	100	
Average		**91**	**100**	**100**	**97.0**
Grand mean		**88.3**	**100**	**99.3**	

These data support the visual impressions (see some of the previous presented pictures taken on June 30 and July 1, 2010) that almost all of the flowers were acceptable after removal from storage, regardless of treatment. The only exceptions were that a few 'Freedom' roses exhibited some petal darkening of the petals and control flowers (all cultivars) looked somewhat more dehydrated upon removal from storage compared to the CA FILMS™ and vapor barrier packed flowers. However, they were not so dehydrated that similar commercial shipments would have all been rejected, but some may have been questioned for those receivers not experienced with such dry looking flowers when in fact they often perform better than ones seemingly fully hydrated.

While some may suggest from the data presented in the table that the CA FILMS™ stored 'Freedom' exhibited more damaged flowers than either of the other two treatments, statistical analysis would not support this contention, even at the very liberal 10% significance level. In addition, it should be noted that the flowers, plastic sleeves and inside of the bags in the CA FILMS™ treatments were visibly much wetter than the other treatments. However, no visible Botrytis was noted on these flowers or on all of the rest of the flowers, regardless of treatment, at the start of the vase life test.

Observations made during the vase life test suggests that flower opening for the control and vapor barrier 'Engagement' flowers may have been slightly less than CA FILMS™ and that CA FILMS™ treated ones may have taken up more flower food solution and therefore exhibited bigger flowers. These subjective impressions could not be confirmed with actual measurements, but the following two pictures taken on July 6, 2010 attempt to show the flower size relationships. No differences were noted for 'Freedom' and 'Vendela'.

Cont. = control, VB = vapor barrier, and CA FILMS™ = MAP

The following 11 pictures depict the appearance of the roses removed from storage on July 7, 2010; some 27 days after the flowers were harvested in Ecuador. Cont. = control, VB = vapor barrier, and CA FILMS™ = MAP.

'Freedom'

'Freedom'

'Freedom'

‘Engagement’

‘Engagement’

‘Engagement’

‘Engagement’

‘Vendela’

‘Vendela’

‘Vendela’

'Vendela'

Based on what is revealed in the above pictures and what was reported to me by the person* who took the pictures, the following comments can be made.

- The CA FILMS™ treated roses looked better than the no vapor barrier controls for all three cultivars, whereas the no vapor barrier controls looked more dehydrated.

- CA FILMS™ treated 'Freedom' looked better than the vapor barrier treated ones.

* The person who took the pictures is my son Greg. He is a 1993 graduate of UCDavis in Environmental Horticulture and was the one who selected the farm in Ecuador, arranged to get the flowers from the farm to Sacramento, and is a flower buyer as a profession. Therefore, his comments are important from a commercial perspective and are reflected in the comments presented above summarizing what he saw and the pictures captured.

Data in the following table presents a summary of the vase life data obtained averaged over seven stems per replicate.

Rose vase life after 20 days of static and transport storage as influenced by packaging treatment.

Treatment	Rep	'Freedom'	'Vendela'	'Engagement'	Grand mean
Control	1	8.9	11.9	6.6	9.1
"	2	9.6	12.9	6.3	9.6
"	3	10.9	14.0	7.7	10.9
"	4	9.9	10.6	7.0	9.2
Average		**9.8**	**12.3**	**6.9**	**9.7**
CA FILMS™	1	10.6	14.4	8.9	11.3
"	2	11.1	13.4	9.0	11.2
"	3	11.3	13.4	9.3	11.3
"	4	10.9	13.1	8.7	10.9
Average		**11.0**	**13.6**	**9.0**	**11.2**
Vapor Barrier	1	10.1	12.1	7.0	9.7
"	2	10.7	12.0	8.1	10.3
"	3	10.6	11.1	5.4	9.0
"	4	9.7	15.1	8.0	10.9
Average		**10.3**	**12.6**	**7.1**	**9.9**
Grand mean		**10.4**	**12.8**	**7.7**	**10.3**

The above data indicates the following.

- The most obvious result, as expected, is that vase life was greatly influenced by cultivar, regardless of packaging differences.

- Analysis of variance calculations in which the replicates were combined leaving 9 degrees of freedom in the error term revealed that there were no treatment differences with 'Vendela', differences at the 10% level with 'Freedom', and significant treatment differences at the 5% level with 'Engagement'.

- Within 'Engagement', the honest significant difference (hsd or Tukey) multiple range test at 0.05 revealed that CA FILMS™ was better than both control and vapor barrier treatments.

- Within 'Freedom', the hsd test at the 0.05 level showed no differences but at an estimated hsd level of 0.07, CA FILMS™ was better than the no vapor barrier controls but the same as the vapor barrier treatment.

It can be concluded that while there were some promising signs that your CA FILMS™ technology helped extend the storage, visual, and/or vase life of some rose cultivars reported herein, much needs to be done before possible commercial utilization can become a reality. Indeed, while roses are considered the number one high value crop that

would benefit from CA FILMS™ technologies, cultivar differences noted in this test and presented in the literature from many other tests remain a significant barrier to a sustainable CA FILMS™ business with roses and many other flower species.

In a 1982 published review of CA and modified atmosphere packaging (MAP) technologies, I wrote the following.

> "Much of the (modified atmosphere) research prior to 1977 has been summarized (Staby, 1977) with the general conclusion that low oxygen, high nitrogen, and/or high carbon dioxide storage systems are not acceptable for the storage of cut flowers. While it is true that some species/cultivars can respond favorably, commercial implementation is considered to be doubtful because the margin of safety is small before phytotoxicity occurs, costs are high, and there is not enough volume of any one cultivar to warrant its use."

What if anything has changed in the floral industry since 1982 that may alter this conclusion? The main change is the increased use of sea containers to transport flowers long distances under proper temperatures. It is therefore conceivable that MAP (or CA) would likely have a greater chance of success when used for storage and/or sea container transport assuming that only species and cultivars that benefit from these technologies are utilized. The trick therefore is to have the patience and money to determine which species and cultivars benefit from MAP (such as 'Engagement') and not go off halfcocked resulting in some failures that would greatly impede commercial implementation into a successful business. In this regard, it would be most useful for you to try to obtain the test results being developed by Fresh Flower Solutions, which is a joint effort involving TransFresh and Flower Auction Aalsmeer (FloraHolland), as they have been shipping many sea container tests of flowers, reportedly under CA conditions.