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NCCC-212 State Report 2020 – USDA, Beltsville, MD, Lewers  
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**Objective 1 - Develop improved small fruit germplasm through cooperative breeding and evaluation programs:**

*Strawberry:*

Title: *Strawberry cultivar development.* Kim Lewers, USDA, Beltsville, MD;

Dissemination:

Lewers, K.S., P. Castro, J.F. Hancock, C.K. Weebadde, J.V. Die, and J.L. Rowland, 2019.

Evidence of epistatic suppression of repeat fruiting in cultivated strawberry. BMC plant biology, 19(1), p.386-403. <https://doi.org/10.1186/s12870-019-1984-7>

Lewers, K.S., M.J. Newell, E. Park, and Y. Luo. 2020. Consumer preference and physiochemical analyses of fresh strawberries from ten cultivars. Int. J. Fruit Sci.

<https://doi.org/10.1080/15538362.2020.1768617>

Lewers, K.S., J.M. Enns, and P. Castro. 2019. 'Keepsake' strawberry. HortScience 54(2):362-367.

Lewers, K.S. 01/22/2018 New Varieties - Review of Releases from Various Programs.

Standouts from each. 2018 North American Strawberry Growers Association Meeting, New Orleans, LA. (Presented by Kevin Schooley due to Federal government shut-down)

Lewers, K.S. 02/27/2018 What makes low tunnels work? Mid-Atlantic Strawberry Association. Virginia Beach, VA.

Lewers, K.S. 05/22/2019 Update from the USDA-strawberry breeding program at Beltsville. 2019 UMD Wye Research Center Strawberry Twilight Meeting. Queenstown, MD.

Lewers, K.S. 02/22/2019 UMD and USDA focus on strawberry flavor. 2019 Bay Area Fruit Meeting. Queenstown, MD.

Lewers, K.S. 02/04/2019 Developing strawberry cultivars with improved fruit quality. 2019 North American Strawberry Symposium. Orlando, FL.

Lewers, K.S. 01/31/2019 Putting flavor and disease resistance first in a strawberry breeding program. 2019 Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA.

Lewers, K.S. 11/27/2018 Wye and USDA updates. 2018 Grower Client Meeting, Bob Rouse Agriculturalist, LLC. Denton, MD.

Lewers, K.S. 12/02/2019. Beltsville update. 2019 Grower Client Meeting, Bob Rouse Agriculturalist, LLC. Denton, MD.

Lewers, K.S. 11/19/2019 Strawberry Cultivars and Production Options at the UMD Mid-Atlantic Crop Management School. Ocean City, MD.

Lewers, K.S. 01/20/2020 Introducing the New Strawberry Keepsake. 2020 North American Strawberry Growers Association Meeting. San Antonio, TX.

Lewers, K.S. 01/13/2020 Strawberry variety testing and quality evaluation and the strawberry breeding program at USDA, Beltsville. Delaware Ag Week – Fruit Session. Harrington, DE.

Lewers, K.S. 03/03/2020 New USDA strawberry cultivar and low-tunnel tips. Mid-



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Atlantic Strawberry Association. Virginia Beach, VA.  
Lewers, K.S. 02/13/2020 New cultivars and low-tunnel films × cultivar interactions. UMD  
Western Maryland Research and Education Center, Keedysville, MD.  
Future plans: Release B2360 as 'Cordial', a late-season spring-fruited strawberry.

**Objective 2 - Develop practices for small fruit production tailored for climatic and market needs of growers.**

*Strawberry:*

Title: *Strawberry production in low tunnels.* Kim Lewers, Dave Fliesher, Craig Daughtry, Brian Vinyard, USDA, Beltsville, MD

Dissemination:

Lewers, K.S., D.H. Fleisher, C.S.T. Daughtry, and B.T. Vinyard. 2020. Low-tunnel strawberry production: Comparison of cultivars and films. *Int. J. Fruit Sci.*  
<https://doi.org/10.1080/15538362.2020.1768616>  
Lewers, K.S. 01/11/2018 Growing Great Strawberries in the Mid-Atlantic. 2018 CASA Future Harvest Conference, Hyattsville, MD.  
Lewers, K.S. 11/28/2017 What makes low tunnels work? 2017 Grower Client Meeting, Bob Rouse Agriculturalist, LLC. Denton, MD.  
Lewers, K.S. 02/02/2017 Low tunnels for strawberry production. 2017 Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA.  
Lewers, K.S. 11/27/2018 Wye and USDA updates. 2018 Grower Client Meeting, Bob Rouse Agriculturalist, LLC. Denton, MD.  
Lewers, K.S. 11/07/2019 Cover crops in strawberry production at the 2019 Northeast Cover Crop Council Conference. College Park, MD.  
Lewers, K.S. 11/02/2019 Strawberry cultivars and production practices for the Mid-Atlantic. 16th Annual Small Farm Conference, UMD Eastern Shore Extension Demonstration Farm, Princess Anne, MD.  
Lewers, K.S. 12/02/2019. Beltsville update. 2019 Grower Client Meeting, Bob Rouse Agriculturalist, LLC. Denton, MD.  
Lewers, K.S. 11/19/2019 Strawberry Cultivars and Production Options at the UMD Mid-Atlantic Crop Management School. Ocean City, MD.  
Lewers, K.S. 01/21/2020 Winning combinations of dayneutral cultivars and low-tunnel films. 2020 North American Strawberry Growers Association Meeting. San Antonio, TX.  
Lewers, K.S. 03/03/2020 New USDA strawberry cultivar and low-tunnel tips. Mid-Atlantic Strawberry Association. Virginia Beach, VA.  
Lewers, K.S. 02/13/2020 New cultivars and low-tunnel films × cultivar interactions. UMD Western Maryland Research and Education Center, Keedysville, MD.  
Future plans: Use low-tunnels for Objective 1 to breed repeat-fruited strawberry cultivars.



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### **Objective 3 - Explore the association between fruit constituents and human health impacts**

*Strawberry:*

Title: *Effects of low-tunnel production system on strawberry fruit constituents.* Tianbao Yang, Kim Lewers, Craig Daughtry, USDA-Beltsville

Dissemination:

Dong, W., Y. Lu, T. Yang, F. Trouth, K.S. Lewers, C.S. Daughtry, and Z.M. Cheng, 2019.

Effect of Genotype and Plastic Film Type on Strawberry Fruit Quality and Post-Harvest Shelf Life. Int. J. Fruit Sci. <https://doi.org/10.1080/15538362.2019.1673873>

Future plans: None

### **3. News and summaries.**

#### **Cultivars:**

‘Flavorfest’ is a mid-season, spring-bearing cultivar that has been out awhile and liked for **reliably high yield and good flavor**. It is resistant to anthracnose fruit rot in the *Colletotrichum accutatum* complex growing naturally in our fields. Some growers and nurseries report that ‘Flavorfest’ flavor is better on clay soils than sandy soils. North Carolina reports it no longer yields well there (reason unknown). Some plug plants have been infected with *Phytophthora* when sold to growers and have died in plasticulture. This has not been widely reported with bare-root dormant plantings in matted-row systems. Supply is good for bare-root dormant plants, but struggling with plug plants.

‘Keepsake’ is a newer mid-season, spring-bearing cultivar, also resistant to *C. accutatum* complex in our fields. This is the first cultivar resulting from our increased emphasis on postharvest quality, so this cultivar should be recommended to growers who need their strawberries to have **longer shelf life**. It also **excels in sweetness** and flavor, even better than ‘Flavorfest’ and ‘Earliglow’. Its yield is very good, but slightly lower than ‘Flavorfest’. Only a few nurseries are licensed.

‘Cordial’ is a **late-season** cultivar in the process of release. It also is resistant to *Colletotrichum accutatum* complex growing naturally in our fields. It has very high yields of **very large fruit**...redefines “large” for our program. Postharvest storage quality is as good as ‘Keepsake’. The fruit are subacid, pH is higher than that of ‘Flavorfest’ and ‘Earliglow’, so without sunshine, the flavor is still friendly or “cordial”. With sunshine, the flavor is sweet but not tart. A few nurseries have test plants under MTAs.

#### **Genetics: Repeat fruiting controlled by one mapped gene and at least two suppressors**

Strawberry repeat fruiting was mapped by several groups to a single locus. I mapped it to the same locus in two populations segregating for other traits, and also confirmed repeat fruiting is conferred by the dominant allele at that locus. But when I tried to apply the markers to the breeding program, they weren’t helpful. I used all the markers



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from the entire linkage group the repeat-fruiting locus mapped to so there would be no chance of disassociation due to recombination. And I tested those markers on all the parents of all the families I used one year to try to breed for a repeat-fruiting strawberry cultivar.

Problem 1: If the markers said the parent should be once fruiting, it was. BUT if the markers said the parent should be repeat fruiting, there was only a 50-50 chance that it would be. It is true that once-fruiting genotypes can, in cool weather, sometimes fruit out of season like repeat-fruiting genotypes. This has made us feel that it would be impossible to discern between genetic and environmental effects. However, it wasn't the parents that had all the markers for once-fruiting that showed inconsistent phenotypes. It was the parents that showed markers for repeat fruiting that had phenotypes that didn't agree with the markers. The fact that half the parents with repeat-fruiting markers behaved as once-fruiting, pointed to a second gene suppressing the one we all mapped.

Problem 2: The only segregation ratios I should have seen in the resulting families from a cross of two repeat-fruiting parents were all repeat-fruiting or 3 repeat-fruiting : 1 once-fruiting. But there were many other segregation ratios from large families. I knew repeat fruiting genotypes could be homozygous or heterozygous at the mapped locus, and once-fruiting would be homozygous recessive at that locus. I considered that the suppressor gene could either be dominant or recessive and would be unlinked to the one we all mapped. I considered every possible parental combination and calculated all possible resulting segregation, and compared them with what I observed. The table below is handy as a quick key to understanding the genetics behind the segregation ratios for this and other traits that don't behave simply. Red text indicates the "informative ratios" that are not seen with a single locus and differentiate between a dominant vs recessive suppressor. It's the suppressor genes that are sensitive to temperature; one to heat, the other to winter cold.

Table 3 Possible segregation ratios of progeny resulting from crosses of repeat-fruiting (RB) and once-fruiting (jb) commercial strawberry parents. Possible progeny ratios are listed on the left. Parental combinations that would result in each segregation ratio are provided for the known mapped dominant gene conferring repeat fruiting with no suppressor, with a hypothetical dominant suppressor, or with a recessive suppressor of the known dominant gene.

Progeny ratios	No suppressor			Dominant suppressor			Recessive suppressor		
All RB	RBxRB	RB and jb		RBxRB	RB and jb		RBxRB	RB and jb	<b>jbxbjb</b>
1jb:3RB				RBxRB			RBxRB	<b>RB and jb</b>	
<b>3jb:5RB</b>							<b>RBxRB</b>	<b>RB and jb</b>	
<b>7jb:9RB</b>							<b>RBxRB</b>	<b>RB and jb</b>	
1jb:1RB		RB and jb			RB and jb	jbxbjb		RB and jb	jbxbjb
5jb:3RB					RB and jb			RB and jb	
3jb:1RB	RBxRB				RB and jb	jbxbjb		RB and jb	jbxbjb
<b>13jb:3RB</b>						<b>jbxbjb</b>			
<b>7jb:1RB</b>						<b>jbxbjb</b>			
All jb			jbxbjb	RBxRB	RB and jb	jbxbjb			jbxbjb





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**New disease in our fields, *Colletotrichum siamense*:**



A species from the dreaded *Colletotrichum gloeosporioides* complex has arrived (confirmed by Mengjun Hu, UMD). It's in our seedling field, so that means it's "native". This is terrible for growers, chaining them to fungicides until resistant cultivars can be developed. But the good news is that not all our families had dead plants, and some families showed live plants among a few dead ones. There were parents in common between families with a lot of dead plants. Therefore, I have high hopes this means our program has some genetic resistance, and we can release resistant cultivars now that the pathogen is in our fields.

**4. Publication summary**

- Lewers, K.S., D.H. Fleisher, C.S.T. Daughtry, and B.T. Vinyard. 2020. Low-tunnel strawberry production: Comparison of cultivars and films. *Int. J. Fruit Sci.* <https://doi.org/10.1080/15538362.2020.1768616>
- Lewers, K.S., M.J. Newell, E. Park, and Y. Luo. 2020. Consumer preference and physiochemical analyses of fresh strawberries from ten cultivars. *Int. J. Fruit Sci.* <https://doi.org/10.1080/15538362.2020.1768617>
- Lewers, K.S., P. Castro, J.F. Hancock, C.K. Weebadde, J.V. Die, and J.L. Rowland, 2019. Evidence of epistatic suppression of repeat fruiting in cultivated strawberry. *BMC plant biology*, 19(1), p.386-403. <https://doi.org/10.1186/s12870-019-1984-7>
- Lewers, K.S., J.M. Enns, and P. Castro. 2019. 'Keepsake' strawberry. *HortScience* 54(2):362-367.
- Dong, W., Y. Lu, T. Yang, F. Trough, K.S. Lewers, C.S. Daughtry, and Z.M. Cheng, 2019. Effect of Genotype and Plastic Film Type on Strawberry Fruit Quality and Post-Harvest Shelf Life. *Int. J. Fruit Sci.* <https://doi.org/10.1080/15538362.2019.1673873>