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Frost Damage of Carinata Grown in the Southeastern US[1]

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Brassica carinata, sometimes called Ethiopian mustard, Abyssinian mustard, or simply carinata, is an annual oilseed crop used for the commercial production of jet fuel. Carinata by-products include seed meal for animal feed (Agrisoma 2017), and residue may act as a bio-suppressant against nematodes (Oka 2010). It is similar to canola in growth habit. It is grown during the winter in the southeastern United States and shows potential as an alternative winter crop for the region.

One of the challenges to commercialization of this crop in the region has been frost damage. Since the crop is planted in the late fall, temperatures can sometimes fluctuate between 50°F (10°C) during the day to 20°F (-6.7°C) that same night, giving the crop little time to harden off. Susceptibility to frost damage depends on temperature, duration at a given temperature, and crop growth stage. Genotype screening trials throughout the Southeast are underway to identify more frost-tolerant cultivars.

This document serves as a guide to identify levels of frost damage as well as management issues related to frost damage of carinata in the Southeast. Be aware that this is a new crop to the Southeast and research on this topic is ongoing. This publication represents the latest information available. More information about carinata production in Florida is available from Seepaul et al. (2015) at http://edis.ifas.ufl.edu/ag389.

Symptomology

The severity of frost damage depends on the crop stage. At the seedling stage when roots are shallow and there are no carbohydrate reserves, frost can kill the crop. At the rosette stage, leaves protect the growing point and roots are deeper, resulting in greater frost tolerance, although leaf tissue damage can occur. After bolting, the stalk and growing points are most susceptible to frost damage. Stalk damage typically results in tissue damage several inches above the soil surface, where structural stresses are high. Death of the

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growing point commonly results in new shoot growth from the crown of the plant.

Minor frost damage first appears as wilting of the leaves, and within about one week presents as bleaching of the leaves, particularly near the tips and leaf margins (Figure 1). If frost damage is more severe, these areas may become necrotic, but the plant is expected to outgrow this level of damage with minimal yield loss (Figure 2).

Figure 1. Leaf bleaching is typically evident 1–2 weeks after a freeze event in carinata. The crop will outgrow this type of damage. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: M. J. Mulvaney, UF/IFAS

Table 1. Cumulative hours below temperature thresholds four weeks prior to the date the photos in Figure 1 were taken.

Planted	2-Nov-2017
Photo taken	20-Dec-2017
Temperature	**Cumulative Hours Below**
32°F (0°C)	30.5
25°F (-3.9°C)	0.0
20°F (-6.7°C)	0.0
15°F (-9.4°C)	0.0

Figure 2. Tissue affected by cold damage may become necrotic. The crop will outgrow this level of damage. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: M. J. Mulvaney, UF/IFAS

Table 2. Cumulative hours below temperature thresholds four weeks prior to the date the photo in Figure 2 was taken.

Planted	23-Nov-2015
Photo taken	8-Jan-2016
Temperature	**Cumulative Hours Below**
32°F (0°C)	10.3
25°F (-3.9°C)	0.0
20°F (-6.7°C)	0.0
15°F (-9.4°C)	0.0

Severe cold damage is shown in Figure 3. This level of damage is expected to reduce crop stands and yield. Note that the aboveground tissue was severely affected, but the roots did not die. The plants in Figure 3 grew back from the growing point, but may have also resprouted at the crown if the roots did not freeze. Replanting of this field is not recommended due to lateness and expected continued crop growth.

Figure 3. More severe cold damage of carinata during early bolting. This level of damage is expected to reduce stands and yield. Note that aboveground tissue was severely affected, but neither the growing points nor roots died. This field generally grew back from the growing point, but could have resprouted at the crown if the damage was more severe. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: M. J. Mulvaney, UF/IFAS

Table 3. Cumulative hours below temperature thresholds four weeks prior to the date the photo in Figure 3 was taken.

Planted	2-Nov-2017
Photo taken	19-Jan-2018
Temperature	**Cumulative Hours Below**
32°F (0°C)	196.8
25°F (-3.9°C)	63.8
20°F (-6.7°C)	14.5
15°F (-9.4°C)	0.0

After bolting, frost damage of the stalk can be more problematic (Figure 4). Splitting of the stem may be evident between the soil surface and several inches off the ground, but the stalk can freeze without splitting, effectively clogging up the vascular tissue later in the season and presenting as a wilted appearance. When this happens, the stem can hollow out at the point of damage. The weakened stem often results in lodging, though the crop will frequently right itself, giving a "J-stemmed" appearance (Figure 5). The injured stem can serve as an entry point for pests, such as *Sclerotinia* (leading to Sclerotinia stem rot) and yellowmargined leaf beetles (*Microtheca ochroloma* Stål) (Figure 6).

Figure 4. Left: severe frost damage of carinata in Quincy, FL. Note growing point damage on the left and lodging on the right. This crop will regrow from the crown at an approximated 70% yield penalty. Replanting after January 15 may be expected to incur at least 50% yield penalty. UF/IFAS North Florida Research and Education Center, Quincy, FL. Right: Recovery and regrowth after lodging caused by stem weakening during frost. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: Left: R. Seepaul, UF/IFAS. Right: M. J. Mulvaney, UF/IFAS

Table 4. Cumulative hours below temperature thresholds four weeks prior to the date the left photo in Figure 4 was taken.

Photo taken	15-Jan-2014
Temperature	**Cumulative Hours Below**
32°F (0°C)	61.8
25°F (-3.9°C)	19.3
20°F (-6.7°C)	3.5
15°F (-9.4°C)	0.0

Frost damage during pod fill is problematic due to poor seed set and seed abortion. This may cause undeveloped seeds and empty pods, leading to severe crop losses. A crop that has suffered frost damage during pod fill may resprout from the crown. A field suffering this level of damage may be considered a complete loss.

While frost damage can be severe, carinata has shown impressive resiliency. Growers in northwest Florida jokingly call this "the Lazarus crop" because of its ability to apparently come back from the dead. The same plot after a hard frost is shown in Figure 7, where about 25% of the plants suffered mortality. Carinata can promote branching to compensate for stand loss, but there is some evidence that secondary branches may not be as productive as primary branches.

Figure 5. Freeze damage at bolting can cause stem damage, including splitting and/or hollowing of the stem, typically within several inches of the soil surface. Lodging often results, but the plant may continue to grow. In severe cases, regrowth will occur at the crown. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: Left: M. J. Mulvaney, UF/IFAS. Right: P. L. Phillips, UF/IFAS

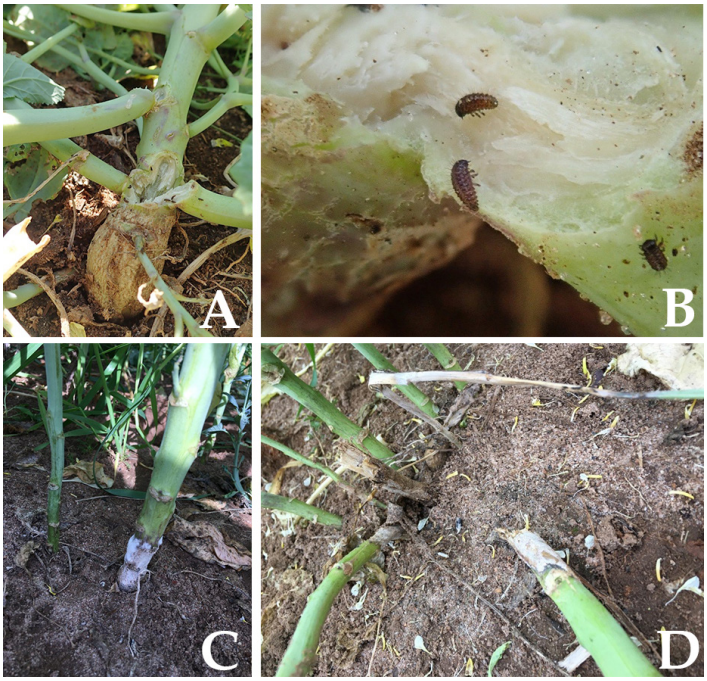

Figure 6. Stalk damage due to frost can lead to pest infestation, such as yellowmargined leaf beetle larvae (A and B), Sclerotinia stem rot (C), and/or stem breakage (A and D). UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: M. J. Mulvaney, UF/IFAS

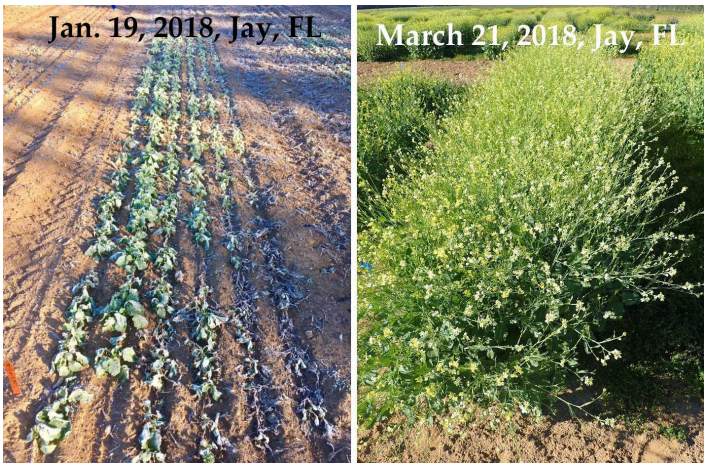

Figure 7. The same carinata genotype shown after a hard frost (left, Jan. 19, 2018) and during flowering (right, March 21, 2018). This plot suffered 25% mortality. Note that increased branching can fill in the gaps, although secondary branches may not be as productive as primary branches. UF/IFAS West Florida Research and Education Center, Jay, FL.
Credits: Left: M. Brown, UF/IFAS. Right: M. J. Mulvaney, UF/IFAS

Table 5. Cumulative hours below temperature thresholds four weeks prior to the date the left photo in Figure 5 was taken.

Planted	16-Nov-2017
Photo taken	19-Jan-2018
Temperature	**Cumulative Hours Below**
32°F (0°C)	196.8
25°F (-3.9°C)	63.8
20°F (-6.7°C)	14.5
15°F (-9.4°C)	0.0

How to Minimize Risk of Frost Damage to Carinata

- A general recommendation is that carinata should be sown approximately six weeks before first frost.
- In the Florida Panhandle, plant carinata during the first two weeks of November. In North Carolina, planting should occur between mid-September and early October. Earlier plantings will reduce yield, and later plantings are more likely to result in small plants at the seedling stage with shallow roots during freeze events. Plants at this stage are more susceptible to frost damage and may require replanting if the roots freeze. Timely planting allows plants to develop into the rosette stage, when frost tolerance is greater, during times when the probability of frost is highest.
- Do not over-apply early-season nitrogen (N). Excessive nitrogen will promote luxuriant growth that is more susceptible to frost damage. Limit at-plant N applications to 20 lbs N/ac or fewer. Calibrate your spreader so you do not over-apply. Topdress N applications are typically made between bolting and flowering.

Be advised that this is a relatively new crop to the Southeast. Ongoing research and new information will change production recommendations. Additionally, promising new carinata varieties with improved frost tolerance and yield gains derived from the breeding program are being developed to fit the expansion of the southern tier commercial production area (Figure 8). Check with your local UF/IFAS Extension agent for the latest production information.

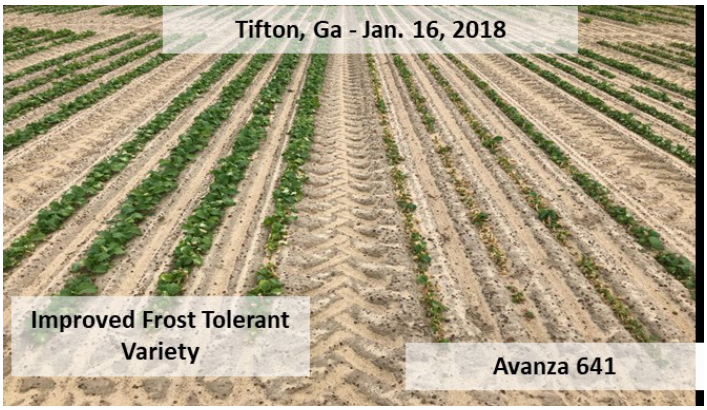

Figure 8. Frost-tolerant carinata lines derived through breeding indicate that promising varieties for tolerating hard freeze events will be available to the region in the near future.
Credits: Agrisoma

References

Agrisoma. 2017. *Southeastern US 2017–18 Carinata Management Handbook*. Accessed on May 7, 2018. https://agrisoma.com/ckfinder/userfiles/files/2017_18_SE_Handbook.pdf

Oka, Y. 2010. "Mechanisms of nematode suppression by organic soil amendments—A review." *Applied Soil Ecology* 44: 101–115. doi: https://doi.org/10.1016/j.apsoil.2009.11.003

Seepaul, R., C. M. Bliss, D. L. Wright, J. J. Marois, R. Leon, N. Dufault, S. George, and S. M. Olson. 2015. *Carinata, the Jet Fuel Cover Crop: 2016 Production Recommendations for the Southeastern United States*. SS-AGR-384. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ag389