



Frost Damage of Carinata

GROWN IN THE SOUTHEASTERN U.S.

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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 its residue may act as a biological suppressant against nematodes (Oka, 2010). It is similar to canola, as it is grown during the winter in the Southeastern U.S. 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 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 the temperature, duration at a given temperature, and crop growth stage. The first signs of frost damage generally appear when temperatures reach below 26 °F (-3.3 °C). Damage at this level generally does not affect yield, but severe damage can be seen when temperatures drop below 22 °F (-5.6 °C). The growth stage of the plant and weather leading up to temperatures in this range determine how this damage affects yields. Carinata is most susceptible to damage in the vegetative and bolting stages. Genotype screening trials throughout the Southeast are underway to identify more frost-tolerant cultivars.

This publication 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 continues. This publication represents the latest information available. More information about carinata production in the Southeast is available from Seepaul, *et al.* (2015).



United States Department of Agriculture
National Institute of Food and Agriculture



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SPARC
Southeast Partnership for Advanced Renewables from Carinata

Symptoms of Frost Damage

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 the roots are deeper, resulting in greater frost tolerance, although leaf tissue damage can still 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 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 the frost damage is more severe, these areas may become necrotic but are expected to recover (Figure 2).

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 is severely affected, but the roots did not die. The plants in Figure 3 grew back from the growing point, but they could have resprouted at the crown if the roots did not freeze. Replanting this field is not recommended due to lateness and because the crop is expected to continue its growth.

FIGURE 1.

Leaf bleaching is typically evident one to two weeks after a freeze event in carinata. The crop will outgrow this level of damage.

UF/IFAS West Florida Research and Education Center, Jay, Florida

Photos: M.J. Mulvaney



Planted: November 2, 2017

Photo taken: December 20, 2017

Cumulative hours below temperature thresholds four weeks prior to the date of the above photos.

Temperature	Hours
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, Florida

Photos: M.J. Mulvaney



Planted: November 23, 2015

Photo taken: January 8, 2016

Cumulative hours below temperature thresholds four weeks prior to the date of the above photo.

Temperature	Hours
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

FIGURE 3.

More severe cold damage of carinata during early bolting. This level of damage is expected to reduce stands and yield. Note that the aboveground tissue is severely affected, but neither the growing points nor roots died. This field generally grew back from the growing point, but the plants could have resprouted at the crown if the damage was more severe.

UF/IFAS West Florida Research and Education Center, Jay, Florida

Photos: M.J. Mulvaney



Planted: November 2, 2017

Photo taken: January 19, 2018

Cumulative hours below temperature thresholds four weeks prior to the date of the above photo.

Temperature	Hours
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). The stem may split 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 wilted. 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 yellow margined leaf beetles (*Microtheca ochroloma* Stål) (Figure 6).

FIGURE 4.

Top: Severe frost damage of carinata in Quincy, Florida. Note the growing point damage on the left and lodging on the right. This crop regrew 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, Florida.

Photos: R. Seepaul



Photo taken: January 15, 2014

Cumulative hours below temperature thresholds four weeks prior to the date of the above photo.

Temperature	Hours
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

Bottom: Recovery and regrowth after lodging caused by stem weakening during frost.

UF/IFAS West Florida Research and Education Center, Jay, Florida

Photo: M.J. Mulvaney



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, Florida

Photos: M.J. Mulvaney (top)
P.L. Phillips (bottom)

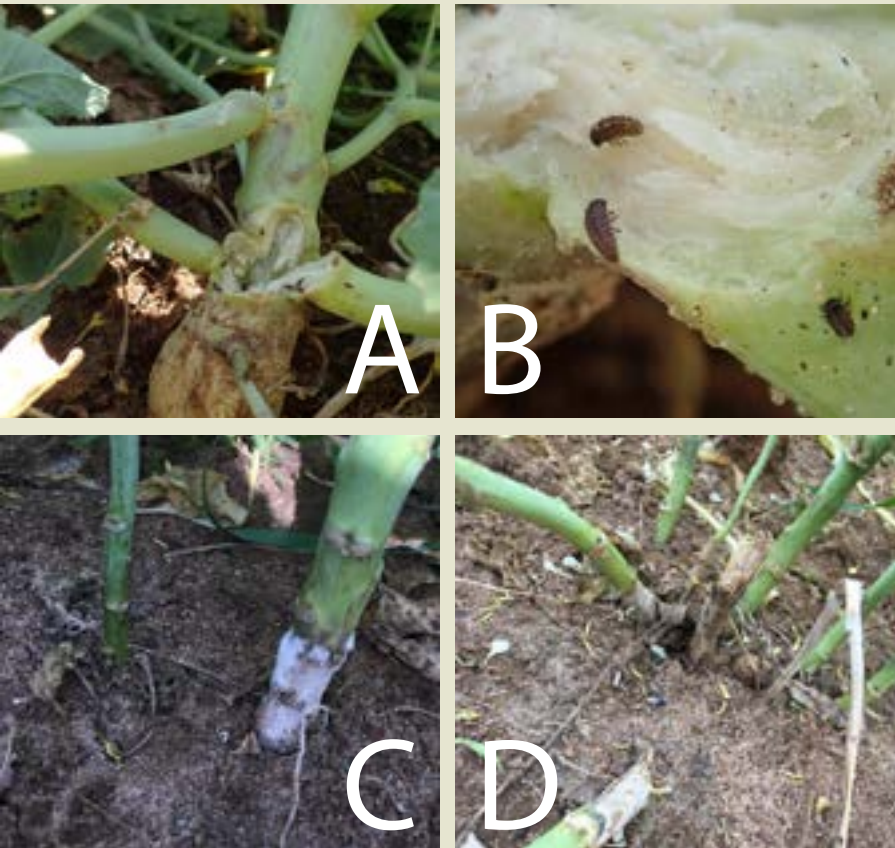


FIGURE 6.

Stalk damage due to frost can lead to pest infestation, such as yellow-margined leaf beetle larvae (A, B), Sclerotinia stem rot (C), and/or stem breakage (A & D).

UF/IFAS West Florida Research and Education Center, Jay, Florida

Photos: M.J. Mulvaney



Frost damage during pod-fill is problematic, resulting in poor seed set and pod 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 “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 7.

The same carinata genotype shown after a hard frost (left: January 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, Florida

Photos: M. Brown (left)
M.J. Mulvaney (right)



Planted: November 16, 2017

Photo taken: January 19, 2018

Cumulative hours below temperature thresholds four weeks prior to the date of the above photos.

Temperature	Hours
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

FIGURE 8.

Severe frost damage in Shellman, Georgia. The damaged plants were unable to recover and ultimately the entire plot was lost to frost damage.

USDA/ARS Shellman, Georgia
Photo: Bill Anderson, USDA/ARS



Planted: November 2, 2017

Photo taken: January 15, 2018

Cumulative hours below temperature thresholds four weeks prior to the date of the above photo.

Temperature	Hours
32 °F (0 °C)	191.8
25 °F (-3.9 °C)	49.3
20 °F (-6.7 °C)	9.5
15 °F (-9.4 °C)	0.0

FIGURE 9.

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.

UGA Tifton campus, U.S. 41 at Zion Hope Road

Photo: Agrisoma



Planted: November 14, 2017

Photo taken: January 16, 2018

Cumulative hours below temperature thresholds four weeks prior to the date of the above photo.

Temperature	Hours
32 °F (0 °C)	83.8
25 °F (-3.9 °C)	14.5
20 °F (-6.7 °C)	0.0
15 °F (-9.4 °C)	0.0

How to Minimize Risk of Carinata Frost Damage

- A general recommendation is that carinata should be sown approximately six weeks before the first frost.
- In south Georgia, plant carinata in the first two weeks of November. In middle Georgia, planting should occur in the last two weeks of October. North Georgia growers should plant even earlier, in the last week of September or first two weeks of October, to ensure that plants are in the rosette stage during the greatest probability of frost. Earlier plantings will reduce yield, and later plantings are more likely to result in small plants at the seedling stage with shallow roots during freezes. Plants at this stage are more susceptible to frost damage and may require replanting if the roots freeze.
- 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/acre or less. Be sure to calibrate your spreader so that you don't over-apply. Topdress N applications are typically made between bolting and flowering.

Be advised that this is a relatively new crop to the Southeast and current varieties have shown severe damage due to unusually cold growing seasons (Figure 8). Ongoing research will change production recommendations as new information is generated. 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 9). Please visit the SPARC website at <https://sparc-cap.org> for the latest production information.

References:

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Acknowledgements:

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award No. 2017-68005-26807. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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