Carinata, the Jet Fuel Cover Crop

2015 Production Manual for the Southeastern United States

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Brassica carinata (carinata) is an oilseed crop with great potential for profitable cultivation in the southeastern US. Its high oil content and favorable fatty acid profile make it suitable for the biofuel industry, especially as a biojet fuel. The University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) North Florida Research and Education Center (NFREC) in Quincy, Florida, has been working to identify advanced carinata genotypes that are high yielding (seed and oil), disease resistant, early maturing, and adapted to the southeastern US. The work at NFREC is being done in conjunction with Agrisoma Biosciences Inc., a company that has the largest carinata germplasm collection, the world's carinata largest breeding program and a variety selection program running in the southeastern and northern prairie states of the US, Canada and several other countries. This publication's "Agronomic Management" section provides recommendations based on research conducted at UF.

Carinata has been grown commercially for several years on the Canadian prairie and more recently in the US northern plains as a summer crop. For the past four years, UF has conducted research to evaluate various management practices that allow incorporation of carinata as a winter crop into current cropping systems with minimal modification to existing infrastructure in the southeastern US. Carinata, also known as "Ethiopian mustard", is a member of the mustard family, native to the Ethiopian highlands.

Carinata is agronomically superior and frost tolerant when compared with other oilseed crops with its larger seed size and lower lodging and shattering rates. It also has a higher oil content (more than 40%).

It is heat- and drought-tolerant as compared to canola. However, it prefers cooler temperatures, making it well suited as a winter crop in the southeastern US.

The benefits of growing carinata as a winter crop are two-fold: (1) increased revenue and (2) ecosystem services. Growing carinata following summer row crops and pastures may be a viable option for many producers.

Figure 1. From field to flight

Additionally, using a winter crop will help to reduce soil erosion, eliminate nutrient losses to water bodies through leaching, increase soil organic matter, and retain soil moisture. Crop diversification will also help to break disease and pest cycles and control weeds.

Carinata is not an invasive plant in the Southeast US. Volunteer seedling emergence in subsequent crops is not an issue when normal site preparation with herbicides is used for weed control.

Background

Carinata Characteristics

Carinata is high in erucic and linoleic acids and has less than 7% saturated fatty acids. These characteristics make it a desirable oil that can be processed into "drop-in" biofuel. Because the oil is high in erucic acid, it is considered a non-food oilseed crop. Carinata has the potential to help meet the renewable energy demands of the United States without posing a threat to food production.

Carinata Biology

In the early stages of growth, plants resemble turnip or mustard. Later, carinata is highly branched and grows as much as 4 to 5 feet high. At maturity, it appears similar to canola. Its extensive deep root system, low canopy temperature, and thick waxy leaves help carinata to be heat- and drought-tolerant. The taproots can reach 2 to 3 feet deep with > 50% of the root system present in the upper 12 inches. In north Florida, the crop cycle ranges from 180 to 200 days depending on variety, row spacing, temperature, and rainfall during seed maturation. When planted in early November, seedling emergence and establishment occurs from 7 to 20 days after planting (DAP), 50% flowering occurs from 110 to 125 DAP, and pod development and maturation occur from 125 to 200 DAP, depending on variety. Flowering/pod set starts from the bottom and progresses to the upper part of the inflorescence with sequential seed maturation.

Pods are 1.5″ to 2″ long with an average of 10 to 16 seeds per pod and a 1000-seed weight ranging from 2.9 to 3.2 grams.

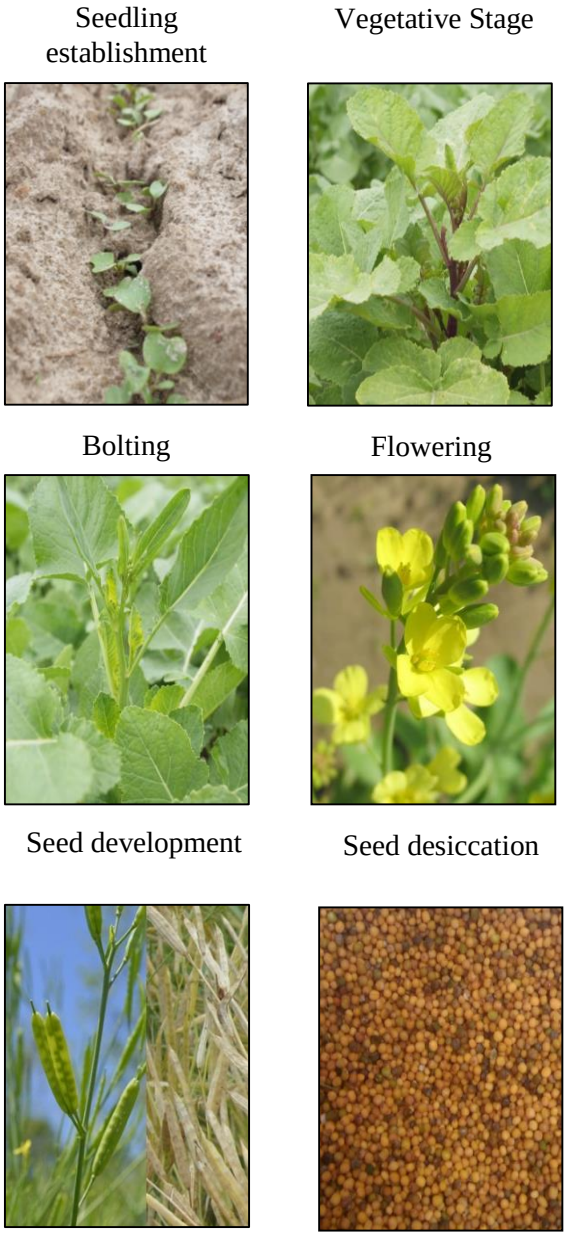

Figure 2. Carinata growth stages

Agronomic Management

Nutrient Management

The nutrient requirements of carinata are similar to canola. Similar to canola, carinata is expected to show a positive response to P and K application if recommended by soil test results. Carinata grows best on well drained soils with pH ranging from 5.5 to 6.8. Soil tests are recommended to determine the fertility status and pH of the fields where carinata will be grown. (http://solutionsforyourlife.ufl.edu/hot_topics/agriculture/soil_testing.html)

Without the benefit of a soil test, the suggested fertilizer application would be (in lb/ac): 80 N, 40 P_2O_5, 80 K_2O, and 25 S for a yield goal of 60 to 75 bu/ac. Similar to N, S is important in protein synthesis but unlike N, S is not mobile within the plant, so a continuous supply of S is needed from seedling emergence to crop maturity. A deficiency of S at any growth stage can result in reduced yields. Split application of N and S is recommended to avoid early season deficiencies and/or excessive leaching. For sandy loam soils, apply 20–30 lb/ac N and 10-15 lb/ac S and all of the P and K fertilizers at planting and the remaining N and S fertilizer at bolting. On deep sandy soils, we recommend a three-way split of fertilizer for

maximum nutrient uptake and less N leaching. At planting or first plant emergence, apply 20-30 lb/ac N, 10-15 lb/ac S, 50% of the K, and all P fertilizer. Apply 20-30 lb/ac N, 10 lb/ac S, and remaining 50% K at bolting. The remaining N fertilizer should be applied at early flowering. Fertilizer may be broadcast and incorporated at planting followed by topdress, sidedress or foliar application through center pivots at bolting and flowering. High N rates at planting or early topdress can cause carinata to have early lush growth making it more susceptible to freeze damage. Boron deficiency occurs in coarse, sandy soils, with pH > 7.0, or during prolonged periods of drought. Use 1 lb/ac of boron either as a pre-pant broadcast or foliar application to reduce deficiencies.

Tillage

Soil type and previous cropping history will influence the type of tillage necessary to prepare the seedbed. Reduced or minimum tillage may increase soil water conservation, soil organic matter, fuel efficiency and erosion control. Carinata can be planted into conventionally tilled or minimum tilled soil, or it may be no-tilled into standing stubble. In 2014/2015, chiseling produced 8% more yield than disking and 33% more yield than no-tillage; a response similar to other small grains with deep tillage. When carinata is no-till planted into sod or other row crop fields, the previous crop residue should be managed for minimum stubble height to allow for good seed-to-soil contact.

A fine and firm seedbed allows for good seed-soil contact, germination, and uniform emergence. If deep tillage is used (turning plow or chisel plow), the area may need to be firmed with a roller, allowed sufficient time for a rain, or irrigated with enough water to create a firm seedbed.

Variety Selection

At NFREC, our evaluations of advanced genotypes to identify high-yielding (seed and oil), disease-resistant, early-maturing lines adapted to the Southeast US are ongoing. From the past three years of evaluations, yield ranged from 2100 to 3600 lb/ac. The commercial variety, AAC A120, produced approximately 2900 lb/ac (58 bu/ac at 50 lb/bu), which is higher than yields reported in northern US states and Canada. At 40% extracted oil content and 3000 lb/ac of seed, carinata will yield 200 gallons of oil per acre with current genotypes having the potential for up to 250 gallons/ac.

Genotype evaluations in the 2014/2015 season identified promising lines that are more tolerant to cold weather extremes, have increased shatter resistance, and higher yielding than last year's commercial variety.

Planting Date

It is recommended that carinata be planted between November 1 and November 30, with preferred planting in early- to mid-November. Earlier and later plantings may incur high incidence of freeze damage, reduced stand density, and reduced yield. Late plantings may result in increased pest damage and late harvest.

Seeding Depth

Carinata should be planted ½″–¾″ deep due to the small seed size. Deeper planting depths should be considered for sandy soils. Fields may be prepared with a drag attached to a cultivator frame to establish a level seedbed. Seed drills should be calibrated to ensure consistent seeding depth and rate.

Seeding Rate and Row Spacing

Carinata is a relatively large seeded mustard (140,000 to 160,000 seeds/lb) and should be planted at 5–6 lb/ac with a target plant density of 8 to 12 plants per sq. ft. Increased plant densities may reduce number of days to maturity. If

Figure 3. Genotype screening at NFREC, Quincy, Florida

seedbed conditions are less than optimum, higher seeding rates should be considered.

Row spacing of 7″ or 14″ is suggested. Row spacing wider than 14″ reduced the ability to compete with weeds and also resulted in significant yield reductions.

Weed Management

Carinata is an aggressively growing crop and will compete with many winter weeds. Wild radish may cause a reduction in harvest value by decreasing oil quality if a significant amount of wild radish seed is included in the harvest. Fields with a history of excessive wild radish should be avoided.

There are several products available for weed control (Table 1). Carinata falls into EPA Oilseed Crop Group 20 and Rapeseed Subgroup 20A where permanent tolerances for a number of selective herbicides have been published in the Federal Register and supports regulatory approvals without additional residue research. Carinata tolerance to commercially available herbicides is continuing to be studied.

Carinata is susceptible to residual herbicides commonly used in cotton-peanut rotations, so it is critical to consider the herbicide history of the field before planting. Herbicides used in cotton-peanut rotations may reduce carinata establishment, growth, and yield.

Figure 4. Fungicide application, Quincy, FL.

Table 1. Registered herbicides for carinata. Always read and follow label instructions before use.

Herbicide	Weeds	Timing	Rate
Aim (Carfentrazone-ethyl EC)	Broadleaf weeds	Pre-plant burndown	Up to 2.0 oz/ac
Select Max, Shadow etc.* (Clethodim)	Grass weeds	According to weed stage	Varies – see label
Roundup (Glyphosate)	Most annual and broadleaf weeds	Pre-plant burndown	Varies – see label
Sharpen* (Saflufenacil)	Harvest aid/desiccation	Pre-harvest, middle pods starting to turn color	1.0-2.0 oz/ac
Treflan 4D etc. (Trifluralin)	Broadleaf and grass weeds	Pre-emergence	Varies – see label

* Suppression only

Table 2 provides crop rotation restrictions for canola for some of the commonly used herbicides. This table may be used as a preliminary guide for carinata rotation intervals. *Check label information for restrictions before planting carinata.*

Fields that meet the aforementioned crop rotational restrictions and only have a recent history of applications of residual herbicides such as Prowl (pendimethalin, Group 3) and non-residual herbicides such as Roundup (glyphosate), Cobra (lactofen), Ultra Blazer (acifluorfen), Butyrac (2,4-DB), and Gramoxone (Paraquat) are less likely to exhibit problems with carinata establishment and growth. These herbicides may be used as a pre-plant weed control. *Check labels before application.*

Table 2. Crop rotation restrictions of some commonly used herbicides for canola based on product label guidelines. Always read and follow label instructions before use.

Trade name	Active ingredient	Crop rotation restriction (months)
Group 2 (ALS-inhibitors)		
Cadre	Imazapic	40
Classic	Chlorimuron	18
Permit or Sandea	Halosulfuron Methyl	15
Pursuit	Imazethapyr	40
Staple	Pyrithiobac sodium	10*
Strongarm	Diclosulam	30*
Group 14 (PPO-inhibitors)		
Reflex	Fomesafen	18
Valor	Flumioxazin	4 to 18**

*With a successful field bioassay
**Depending on quantity applied and tillage

Disease Management

Carinata disease management is similar to canola and other mustards. Scouting for disease is a necessary preventative measure. As with other brassica crops, carinata should not be grown every year on the same field but once every three years to reduce disease problems. Trials and changing regulated guidelines for fungicide use on carinata are ongoing. Table 3 lists approved fungicides for carinata. The following are diseases found during the past three years at NFREC.

White Mold

White mold is caused by *Sclerotinia sclerotiorum*, which may infect carinata at any stage of development. It grows well in wet environments, especially after prolonged rainfall, and produces white, fuzzy growth as a first symptom. Dark or brown stem lesions may also occur. *Sclerotinia* may cause premature seed ripening, shrunken seeds, and shattering. Currently, it is not considered a serious problem in the Southeast US.

Leaf Spot

Leaf spot is caused by *Alternaria* spp., a fungus causing damage to leaves, stems, and pods. Symptoms begin with small, dark circular spots that spread outward. Leaves may wilt and drop, stems may turn dark brown, and pod infection may cause seed darkening and damage. Currently, *Alternaria* is not considered a serious problem in the Southeast US.

Fusarium spp.

Fusarium seed rot causes damage to seed quality specifically reducing oil content and test weight. Warm temperatures and extended periods of moisture promotes infection and disease development. Crop rotation is especially important for decreased risk of disease as Fusarium survives in crop residue.

Turnip Mosaic Virus

Turnip mosaic virus symptoms include chlorotic lesions in a mosaic or mottled pattern on leaves. It may cause premature leaf drop. This disease is usually spread by aphids, which are normally reduced with a frost or cool weather.

Figure 5. Sclerotinia stem and pod infection

Figure 6. Alternaria on leaf, stem, and pod infection

Figure 7. Turnip mosaic virus on carinata

Insect Management

Since carinata is in the same family as canola, other mustards, and cabbage, their insect pests may be similar. Scouting for insect pests is a necessary management practice. Potential pests may include aphids (such as root aphid), cabbage seedpod weevil (*Ceutorhynchus obstrictus*), silverleaf whitefly (*Bemisia argentifolii*), and worm complex, which includes diamondback moth (*Plutella xylostella*), cabbage looper (*Trichoplusia ni*), and cabbageworm (*Pieris rapae*).

During the 2014/2015 season, diamondback moth was present in a few late-planted commercial fields to warrant insecticide application. We do not have data concerning thresholds but hope to determine/establish these in the future. Table 3 provides a list of insecticides registered for use on carinata. *Check label for restrictions.*

Table 3. Registered fungicides and insecticides for carinata. Always read and follow label instructions before use.

Fungicide	Disease/Pest	Timing	Rate
Aproach (Picoxystrobin)	Alteraria black spot, Sclerotinia stem rot	20-50% flowering, or prior to onset of disease	3-12 oz/ac
Endura (Boscalid)	Sclerotinia stem rot	20-50% flowering, or prior to onset of disease	5-6 oz/ac
Quash (Metconazole)	Sclerotinia stem rot	20-50% flowering, or prior to onset of disease	2-4 oz/ac
Priaxor (Fluxapyroxad + Pyraclostrobin)	Alternaria black spot, Sclerotinia stem rot*	Varies according to target disease – see label	4-8 oz/ac
Tilt (Propiconazole)	Alternaria black spot	Prior to bolting	2.6-4 oz/ac
Insecticide			
Coragen (Chlorantraniliprole)	Diamondback moth	Apply as required by scouting	Varies – see label
Mustang Maxx, Mustang Maxx EC (Zeta – Cypermethrin)	Aphid, cutworm, diamondback moth, stink bug	Apply as required by scouting	Varies – see label
Prevathon (Chlorantraniliprole)	Diamondback moth, cutworm, armyworm	Apply as required by scouting	14-20 oz/ac
Intrepid (Methoxyfenozide)	Many insects – See label	Apply as required by scouting	2-24 oz/ac

*Suppression only

Harvest Management

Harvest management practices for carinata are similar to canola. Among the mustards, carinata has the highest level of resistance to pod shattering; however, timing and harvest method are critical for optimum yield and quality. Normal seed desiccation progresses rapidly, indicated by a drop in moisture content from 25% to 8% in 3–4 weeks. This may vary depending on the weather conditions. When the moisture content is 8% to 10%, carinata may be combined. Upper branches and pods will be dry, however, the main stem may still be slightly green. Carinata stalks are tougher than canola or other mustards. Green stems will slow down the harvesting process and use more energy. Allowing the crop to fully mature will reduce harvest time and energy. However, the main stem may still be slightly green when maturity is reached. This will not affect harvest. It is essential to have the proper screens and combine settings to reduce dockage and loss of seed. Use the machine settings for rapeseed outlined in the operator's manual. Ongoing research shows the potential of chemical desiccants to accelerate seed dry-down. Chemical desiccation with Saflufenacil (Table 1) applied when the middle and upper pods are changing color from green to olive green may help hasten carinata harvest and facilitate the timely planting of summer crops.

Figure 8. Harvesting carinata using traditional combine harvester in Quincy, Florida

Economics

Production costs for carinata are very similar to canola. Preliminary economic analysis for carinata is presented in Table 4. Net returns are calculated assuming an average production cost of $275/acre.

Table 4. Net returns as a function of yield and price.

	Net returns per acre		
Price ($/bu)	Yield (bu/ac)		
	50	60	70
8.0	125	205	285
8.5	150	235	320
9.0	175	265	355

Crop Insurance

To reduce economic risks associated with carinata production, crop insurance is available from fall 2015. An XC written agreement will be required to insure carinata in counties without a canola program. In counties with a canola program, a TP written agreement will be required. Requirements for each type of written agreement are slightly different with an XC requiring 3 years of similar crop production. Contact your local crop insurance agent for more information.

Summary

We have identified promising varieties and shown the potential of carinata as an oilseed crop for the Southeast US. Baseline management and agronomic production practices have been developed.

In addition to increased diversification and revenue generation, using carinata as a winter “cash” crop on underutilized or fallow land will improve conservation of nitrogen and water, which reduces input costs and increases ecosystem sustainability. Ongoing research at UF in collaboration with Agrisoma Biosciences Inc. is focused on developing region-specific agronomic production recommendations and improved carinata varieties targeted for double crop production in the southeastern US.