UF IFAS Extension UNIVERSITY of FLORIDA

SS-AGR-384

Carinata Production in Florida[1]

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Brassica carinata is a promising oilseed crop with great potential for profitable cultivation in Florida. Its high oil content and favorable fatty acid profile make it suitable for the biofuel industry, especially as a biojet fuel. The 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 Florida. The work at NFREC is being done in conjunction with Agrisoma Biosciences Inc., a crop company that has the world's largest collection of carinata germplasm. This publication's "Agronomic Management" section provides recommendations resulting from NFREC's research.

Figure 1. From field to flight
Credits: David Wright, UF/IFAS (field, seed); Thinkstock (plane, oil)

Carinata has been grown commercially for several years on the Canadian prairie as a summer crop and more recently in the US northern plains. For the past three years, NFREC has conducted research to evaluate various strategies that allow incorporation of carinata into prevalent cropping systems with minimal modification to existing infrastructure in Florida.

B. carinata, commonly called "Ethiopian mustard," is native to the Ethiopian highlands. Carinata is a member of the mustard family, Brassicaceae, and has a high glucosinolate content. Carinata is agronomically superior to other oilseed crops and mustards with its high oil content (more than 40%), larger seed size, and lower lodging and shattering rates. It is heat- and drought-tolerant and can withstand weather extremes. However, it prefers cooler temperatures, making it well suited as a winter crop in Florida.

The benefits of growing carinata as a winter crop are two-fold: (1) increased revenue and (2) ecosystem services. Carinata is adapted to low-input agriculture and has the ability to grow on marginal land. Growing carinata on fallow row crop and pasture land may be a viable option for many producers. Additionally, using a winter crop will help

1. This document is SS-AGR-384, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date December 2014. Visit the EDIS website at http://edis.ifas.ufl.edu.

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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 to control weeds.

Carinata is not an invasive plant in Florida since it is a cool season crop harvested from late-May to early-June. 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 6 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.

Agronomic Management

Nutrient Management

The nutrient requirements of carinata are similar to canola; therefore the production guide to canola in Florida (Wright, archived EDIS) was referenced. Soil tests are recommended to determine the fertility status and pH of the fields where carinata will be grown. Similar to canola, carinata is

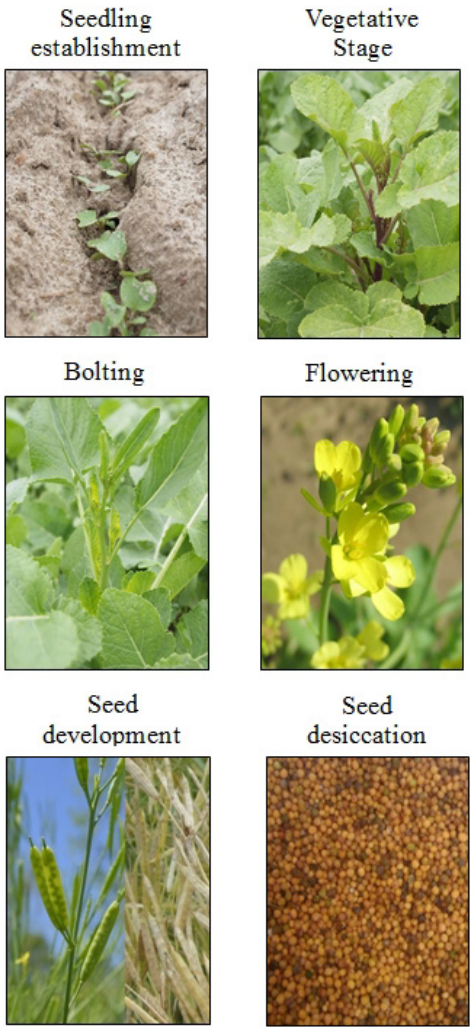

Figure 2. Carinata growth stages
Credits: R. Seepaul, UF/IFAS

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. 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. Split application of N and S is recommended to avoid early season N deficiency and/or excessive N leaching. Apply 20–30 lb/ac N and all of the P and K fertilizers at planting and then the remaining N fertilizer in late January. On very sandy sites, K can be split with 50% application at planting followed by 50% with topdress N at bolting/flowering. High N rates at planting or early topdress can cause carinata to have early lush growth that may make it more susceptible to freeze damage if a severe cold event occurs. Boron deficiency occurs in coarse, sandy soils, in soils with a pH > 7.0, or during prolonged periods of drought. Use the recommended 1 lb/ac of boron either as a foliar or broadcast pre-plant application to reduce possible deficiencies. For soil testing information, refer to http://solutionsforyourlife.ufl.edu/hot_topics/agriculture/soil_testing.html.

Figure 3. Genotype screening at NFREC, Quincy, Florida
Credits: David Wright, UF/IFAS

Tillage

Well-drained soils with row crops are generally most suitable for carinata production. Poorly drained soils should be avoided. Carinata may be planted into conventionally tilled or minimum tilled soil, or it may be direct seeded into standing stubble. However, 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. 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.

Variety Selection

At NFREC, our evaluations on advanced genotypes to identify high-yielding (seed and oil), disease-resistant, early-maturing genotypes adapted to Florida climatic conditions are still ongoing. From the 2013/2014 evaluations, grain yield among 40 genotypes ranged from 1600 to 5000 lb/ac, with a mean of 2900 lb/ac. Available genotype AACA110 produced 3000 lb/ac (60 bu/ac at 50 lb/bu), which is higher than yields reported in northern US states and Canada. At 40% extracted oil content and 3500 lb/ac of seed, carinata will yield 200 gallons of oil per acre with current genotypes having the potential for up to 300 gallons/ac.

Planting Date

It is recommended that carinata be planted from early- to mid-November in Florida. Earlier and later plantings may incur high incidence of freeze damage, reduced stand density, and reduced grain yield. At NFREC, our highest grain yields were produced from the November (3000 lb/ac) planting compared to the October (1000 lb/ac) and December (1500 lb/ac) planting date.

Seeding Depth

Carinata should be planted ½″–¾″ deep due to the small seed size relative to row crops. Planting deeper reduces seedling emergence and results in poor stand establishment. 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

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 square feet (sq ft). Although carinata seems to compensate for low planting densities by increasing branching, replanting should be considered if plant density is < 4 plants/sq ft to prevent significant yield penalties. Higher plant densities may reduce number of days to maturity. If seedbed conditions are less than optimum, higher seeding rates should be considered.

Spacing

Traditional row spacing for most grain drills is 7″, yet 14″ row spacing increased yields at NFREC by 2000 lb/ac in 2013/2014 growing season. Further research is needed to verify this. Row spacing wider than 14″ reduced the ability to compete with weeds and also resulted in significant yield reductions. At 14″ row spacing, plants were well branched with higher pod numbers and seed yield per plant.

Weed Management

Carinata is an aggressive growing crop when planted in November 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 excessive wild radish should be avoided.

There are currently no herbicides labeled for carinata in the United States. However, 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, which supports regulatory approvals without additional residue research. Carinata tolerance to commercially available herbicides is currently being studied. This crop is highly susceptible

Figure 4. Fungicide application, Quincy, Florida.
Credits: David Wright, UF/IFAS

to different 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/or yield. Table 1 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-planting weed control. Check labels before application.

Table 1. Crop rotation restrictions for using common herbicides on canola

Brand 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
Spartan	Sulfentrazone	24
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 regulated guidelines for fungicide use on carinata are ongoing. Both Quadris and Endura fungicides, although not specifically labeled for carinata, are approved for use on Crop Groups that include 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 Florida.

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 Florida.

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.

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,

Figure 5. Sclerotinia stem and pod infection
Credits: R. Seepaul, UF/IFAS

Figure 6. Alternaria on leaf, stem, and pod
Credits: R. Seepaul, UF/IFAS

Figure 7. Turnip mosaic virus on carinata
Credits: R. Seepaul, UF/IFAS

which includes diamondback moth (*Plutella xylostella*), cabbage looper (*Trichoplusia ni*), and cabbageworm (*Pieris rapae*).

During the three years of trials at NFREC, no insect pests have been present in sufficient quantities to warrant treatment. At this time we do not have any data concerning thresholds but hope to evaluate this further in the future. If insect pressure becomes problematic, Coragen insecticide, though not labeled specifically for carinata, is permitted for the Oilseed Group. Check label for restrictions.

Harvest Management

Harvest management practices for carinata are similar to canola. Among the mustards, carinata has high pod shattering resistance; however, timing and harvest method are critical for optimum grain 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 using the machine settings for rapeseed outlined in the operator's manual. Ongoing research shows the potential of chemical desiccants to accelerate seed dry-down. Once labeled for use on carinata, desiccants may help hasten carinata harvest and facilitate the timely planting of summer crops.

Figure 8. Harvesting carinata using traditional combine harvester in Quincy, Florida
Credits: David Wright, UF/IFAS

Production Challenges

Carinata production poses similar challenges as those for canola production. Potential difficulties may include the following:

- **Planting**—Potential yield reduction may occur with planting too early or late. Planting conditions (i.e. seed depth, moisture) may cause a need for replanting in order to counteract yield losses due to low plant density.
- **Frost/freeze damage**—There is a potential of significant cold weather events damaging young plants or plants with early lush growth. Replanting may be needed to offset yield losses.
- **Diseases**—Although significant losses due to disease in carinata have not occurred in Florida, scouting and control may be necessary.

- **Residual herbicide**—Carinata is sensitive to certain residual herbicides, especially routine chemicals applied to cotton and peanuts. Significant crop damage may occur if planted before prescribed planting intervals.
- **Harvesting green, immature stems**—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.
- **Harvest losses**—Allowing pods to dry beyond optimal maturity may result in excessive shattering while harvesting, resulting in considerable loss in yield. Effort should be made to harvest within the recommended seed dryness. Also, proper adjustment of machinery will minimize seed losses during harvest. Equipment should be tested for accurate settings.

Economics

Production costs for carinata are very similar to canola. NFREC does not currently have an economic analysis for carinata but will have that information in the future. We suggest utilizing the following canola guide for production costs: http://extension.uga.edu/publications/detail.cfm?number=B1331.

Figure 9. Carinata has a production cost similar to canola
Credits: David Wright, UF/IFAS

Summary

We have identified promising varieties and shown the potential of carinata as an oilseed crop for Florida. Baseline management and agronomic production practices have been developed for application to large-scale production in fall 2014. Farmers need to consider the herbicide history of fields before planting carinata because of the high susceptibility to ALS (acetolactate synthase) herbicides commonly used in cotton-peanut rotations.

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 NFREC 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 United States.

References

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