Brassica carinata nutrient uptake and partitioning across maturity groups and latitudes

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Rationale

- *Brassica carinata* (carinata), a non-food oilseed feedstock, is of interest due to seed oil physical and chemical properties equivalent to petroleum-derived fuels
- Carinata has demonstrated good yield potential as a winter biofuel crop in the southeastern (SE) United States (US)
- There are limited data regarding temporal nutrient accumulation and partitioning dynamics of carinata. As a recently introduced crop in the SE US, such studies inform the rate of macro and micronutrient accumulation and aid fertility management decisions
- In order to fit *B. carinata* in the existing cotton-peanut cropping system in the SE US, early maturity genotypes are needed. However, nutrient uptake and accumulation data for the recently proposed early maturity genotypes are not well documented in carinata literature.

Research question

What are the season long nutritional requirements of Brassica carinata in the SE US?
Does the nutritional requirement differ among the proposed maturity classes?
Does the nutritional requirement differ across the latitudes for commercial variety Avanza-641 in the SE US?

Objective

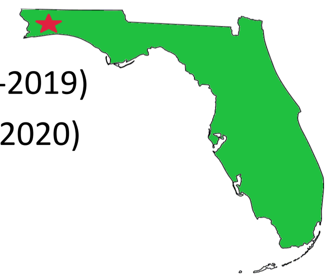
- To quantify seasonal long biomass, nutrient accumulation and partitioning in *Brassica carinata* in SE US conditions
- To determine if nutrient uptake and partitioning will differ among proposed maturity classes for *B. carinata* (early, mid and full season and across different latitude for commercial variety Avanza-641

Materials and methods

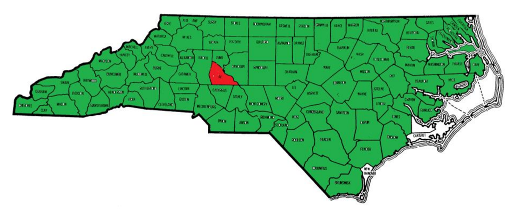
Field sites

Location: Jay, FL (2018-2020)

Soil type: Red bay sandy loam (2018-2019)
Fuquay sandy loam (2019-2020)



Salisbury, NC (2018-2020)
Soil type: Lloyd clay loam (2018-2019), (2019-2020)



Experimental design and setup

Study details

Location: Jay, FL (2018-2019) and (2019-2020)
Salisbury, NC (2018-2019) and (2019-2020)
Design: RCB, reps
Treatment: (3 genotypes)
DH-157.715 (Early season)
M-01 (Mid season)
Avanza-641 (Full season)
Note: Only Avanza-641 was planted across 2 site-years in NC

Biomass and nutrient accumulation:

- Plant tissue samples were sampled at multiple growth stages and partitioned into leaves, stems (petiole plus stem), reproductive parts (flowers and pods), and seed

Measurements and data analysis

- Partitioned biomass was dried and ground to pass a 2mm screen, chemically digested in a digestion block with nitric acid, and subjected to elemental analysis using inductively coupled plasma optical emission spectrometry (ICP-OES)
- Total carbon and total nitrogen were analyzed by dry combustion (AOAC, 2006).
- Total nutrient uptake was determined by multiplying aboveground dry matter yield at maturity by nutrient concentration.

Statistical analyses

- ANOVA using SAS 9.4: PROC GLIMMIX
- Multiple comparisons using tukey-Kramer at 95% confidence level
- Graphs created using ggplot2 version 2.3.3 from R programming language version 4.0.0

Results

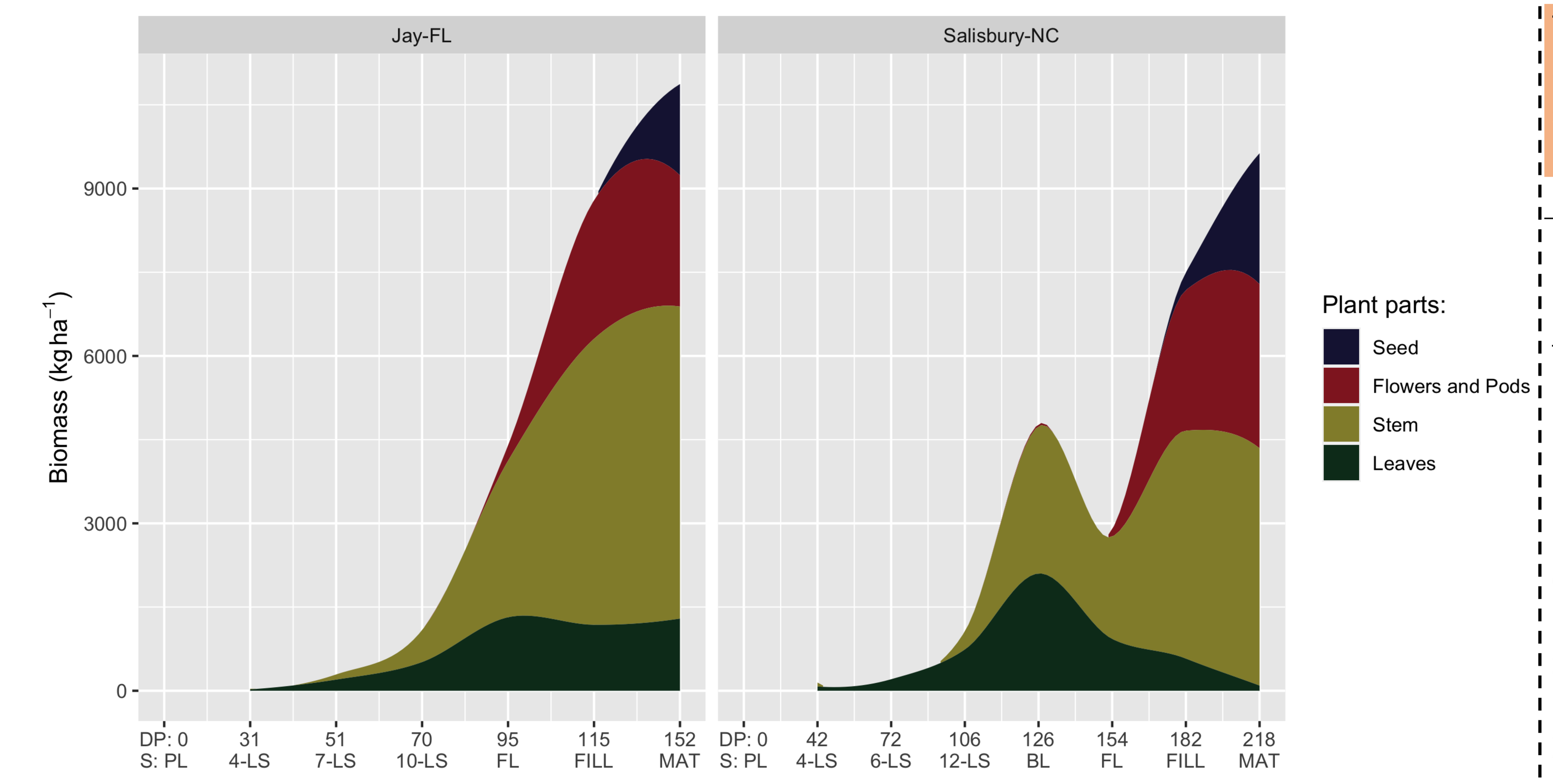


Figure 1. Seasonal biomass accumulation and partitioning averaged over three genotypes and two site years at Jay, FL and averaged over two site years for Avanza-641 genotype at Salisbury, NC during 2018-2019 and 2019-2020 growing seasons. DP represents days after planting and S refers to the growth stages.

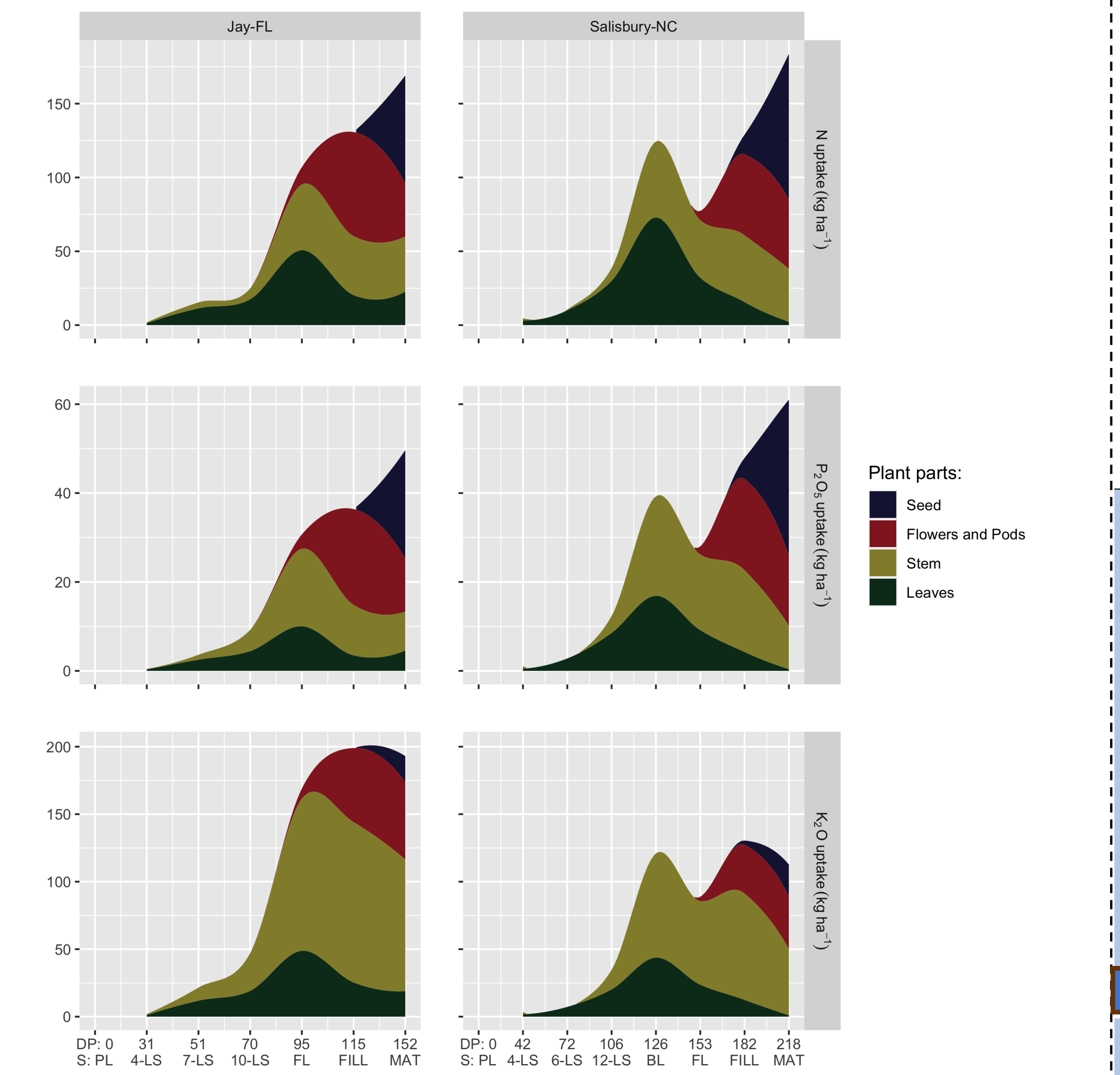


Figure 2. Seasonal accumulation and partitioning of N, P_2O_5 and K_2O averaged over three genotypes and two site years at Jay, FL and averaged over two site years for Avanza-641 genotype at Salisbury, NC during 2018-2019 and 2019-2020 growing seasons. DP represents days after planting and S refers to the growth stages.

Table 1. End of season uptake of macro and micronutrients and nutrient harvest indices averaged over genotypes for (2019-2020) growing season at Jay, FL and combined two site years (2018-2019 and 2019-2020) at Salisbury, NC. Numbers followed by ± represent SEM

Parameter	Total uptake	Removal with grain	Harvest index
		Jay, FL	
	------kg ha^{-1}------		------%------
N	214±39	118±29	55±5
P	30±4	18±3	60±5
P_2O_5	69±9	42±6	60±5
K	168±54	21±5	13±4
K_2O	202±65	26±6	13±4
Ca	134±25	14±3	10±2
Mg	28±6	8±2	29±2
S	74±20	24±6	32±4
	------g ha^{-1}------		
Zn	433±190	130±30	30±5
Mn	376±150	81±16	21±5
B	207±60	38±7	18±3
Fe	1900±1000	265±50	14±7
Cu	39±4	10±2	26±3
		Salisbury, NC	
	------kg ha^{-1}------		
N	184±25	97±20	50±6
P	25±3	14±2	57±7
P2O5	56±7	32±5	57±7
K	133±29	18±4	16±3
K2O	160±35	22±4	16±3
Ca	26±17	10±2	10±2
Mg	106±4	7±1	26±4
S	64±12	21±4	32±4
	------g ha^{-1}------		
Zn	515±104	114±23	22±4
Mn	345±80	70±14	23±5
B	187±38	30±6	17±4
Fe	1203±449	192±42	23±6
Cu	45±12	7±2	22±4

- Total dry matter accumulation in carinata increased 99% from flowering till pod fill and 24% from pod fill to seed maturation in FL (Figure 1). Stem biomass increased 9% from pod fill to maturity in Jay, FL while the reproductive biomass decreased 5%. Stem and reproductive biomass decreased by 24% and 22% respectively from pod fill to maturity in Salisbury, NC (Figure 1). There was also a decrease in total biomass accumulation between bolting and flowering growth stage due to freeze events (Figure 1) which had a deleterious effect on biomass accumulation and nutrient uptake at NC. Peak N and P_2O_5 accumulation occurred at flowering growth stage while peak K_2O accumulation occurred at bolting growth stage in FL (Figure 2).
- Averaged over three genotypes and one site year at Jay, FL, 60% of accumulated phosphorus was removed via harvested carinata seed tissues which were followed by N removal (55%), S removal (32%), Mg removal (29%), K removal (13%) and Ca removal (10%). (Table 1) Similarly, based on average of two site years, 57% of total accumulated phosphorus was removed via harvested carinata seeds followed by N removal (50%), S removal (32%), Mg removal (26%), K removal (16%) and Ca removal (10%) in Salisbury, NC.

Conclusions

- Carinata genotypes in this study exhibited similar nutrient uptake and partitioning (data not shown) indicating that the nutrient management practices may not differ among the recently proposed early maturity genotypes in the SE US
- Timing of nutrient application (particularly N) for the commercial variety Avanza-641 may differ across Jay, FL and Salisbury, NC to mitigate deleterious effects of freeze damage.

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