

9TH ANNUAL CARINATA BIOMATERIALS SUMMIT



.UBA agronomía
FACULTAD DE AGRONOMÍA



Brassica carinata in the Pampas: resource efficiency from root to tip

PhD Deborah Rondanini

University of Buenos Aires, Argentina
rondanin@agro.uba.ar

Why study *B. carinata* in the Pampas?

Intensive agriculture in the fertile plains of South America

Winter crops dominated by cereals (wheat and barley)

Difficult control of foliar diseases and herbicide-resistant weeds

Poor ecosystem service to pollinators

Government interference in wheat prices and taxes



Incorporate new winter crops

Agroclimatic adaptability of *Brassicas*

Experience cropping canola in Argentina and Uruguay

Growing interest in biofuel from *B. carinata*

- Is it efficient in the use of resources?
- How much biomass (from shoot and roots) does it contribute to the farming system?

Experimental approach

Experiment at the School of Agriculture, University of Buenos Aires ($34^{\circ}36'S$ $58^{\circ}26'W$)

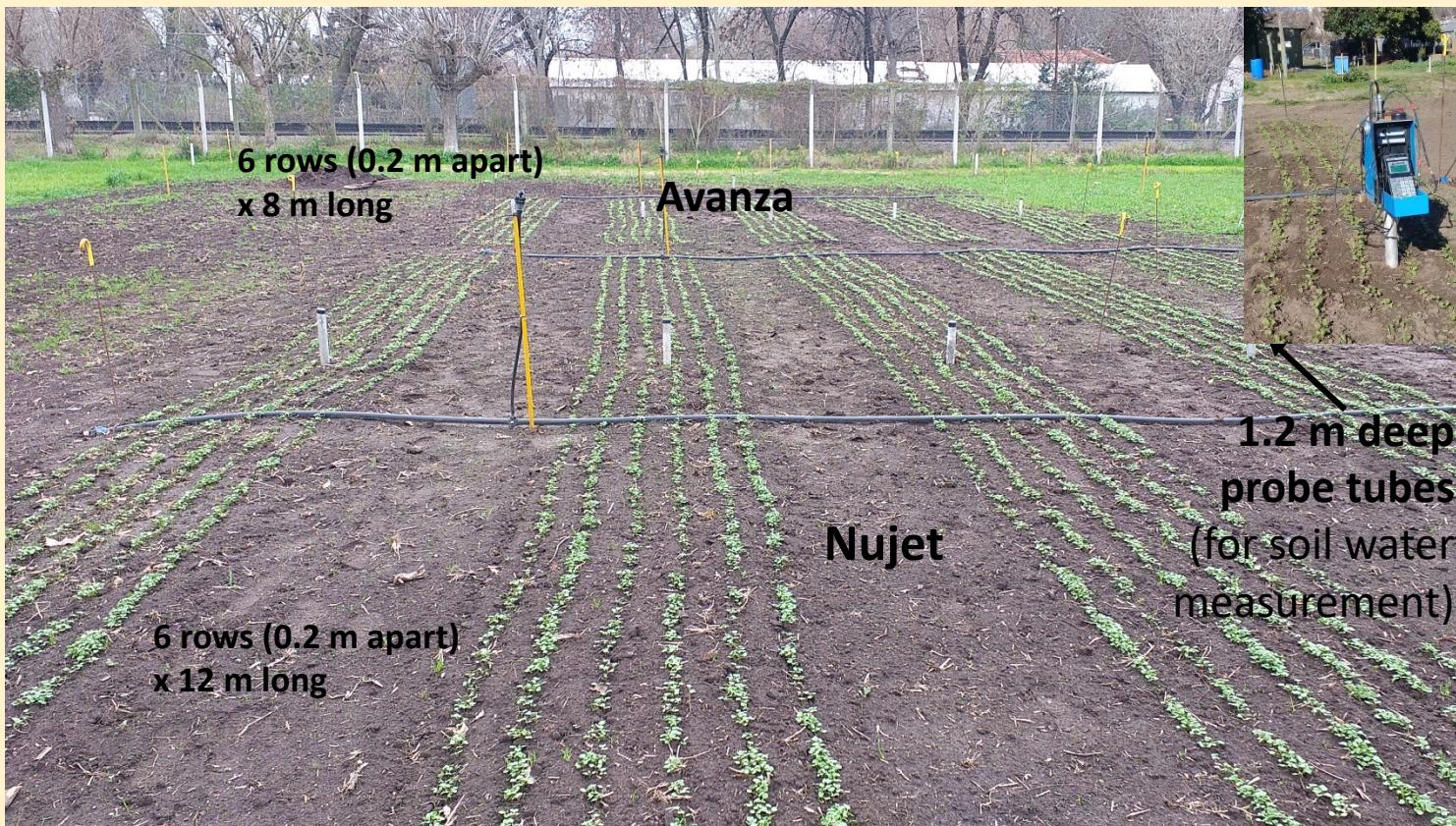
Soil: Typical Argiudoll with a strong clay horizon (Bt) at 40 cm depth

Nujet 400 (hybrid) and **Avanza 641** (OP variety)

Late sowing date: June 23, 2021

Planting rate: 100 plants/m²

Husbandry: **irrigated and fertilized** (up to 100 kg N available/ha) and preventive fungicide in VE and V6



10 days after First
Flowering



Sept 27

55 days after First
Flowering



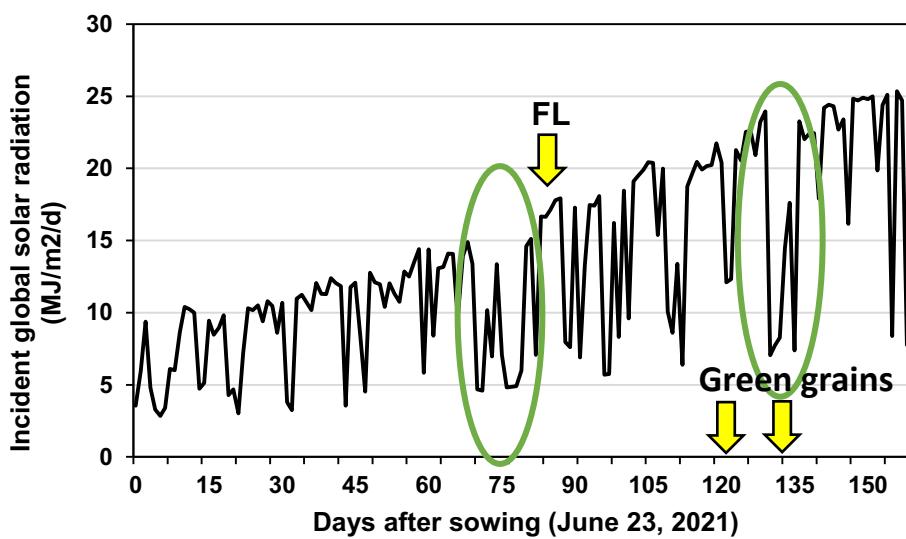
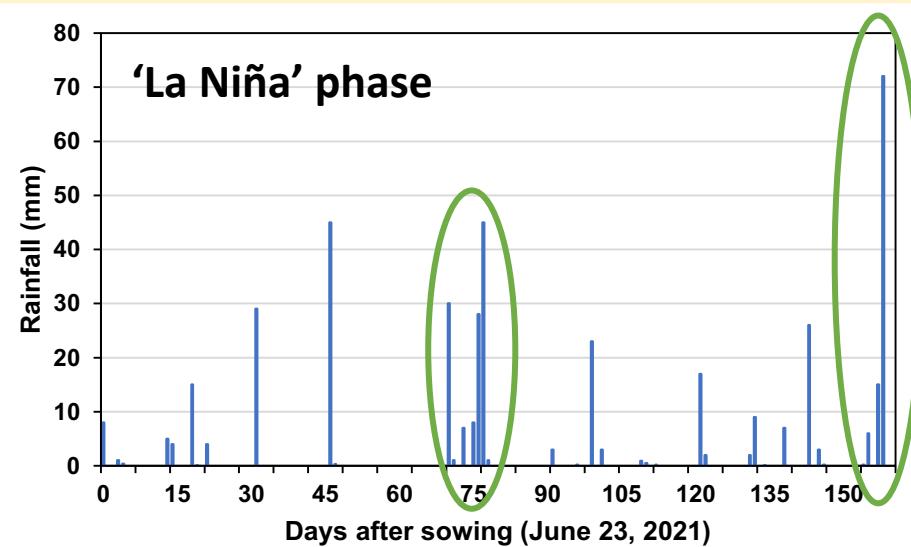
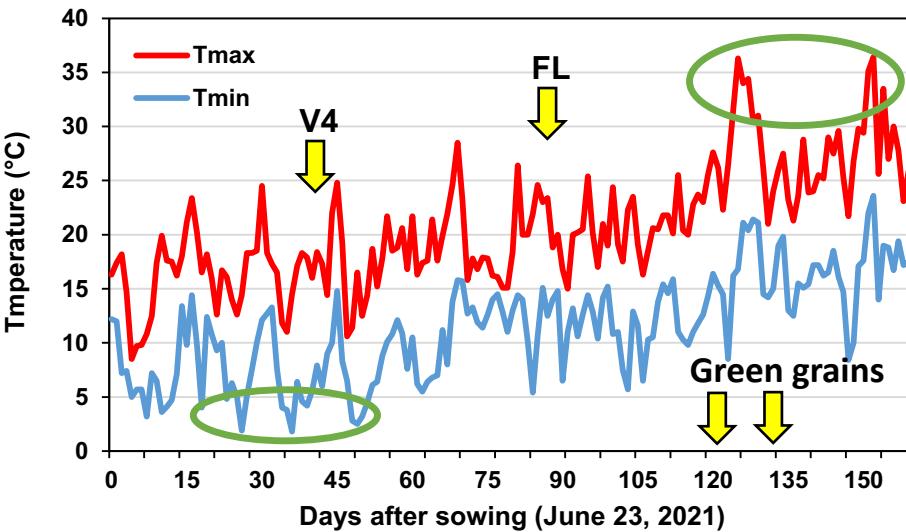
Nov 12

Whole crop cycle: 160 days

First flowering: (17-19 Sept)

55% pre- 45% post- flowering

Meteorological conditions in 2021



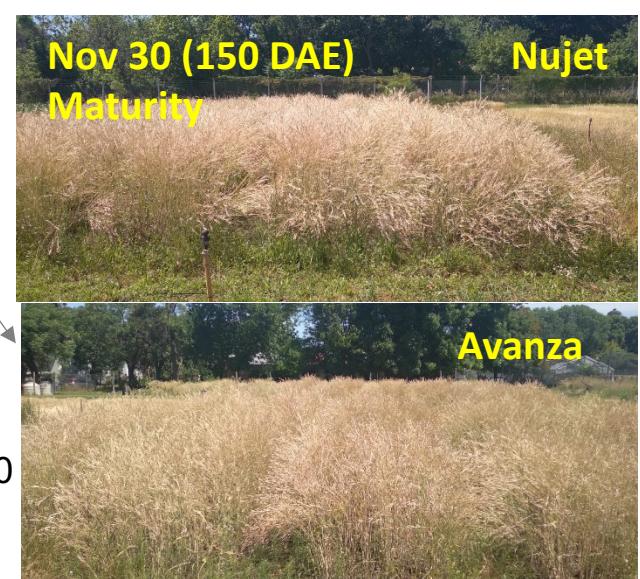
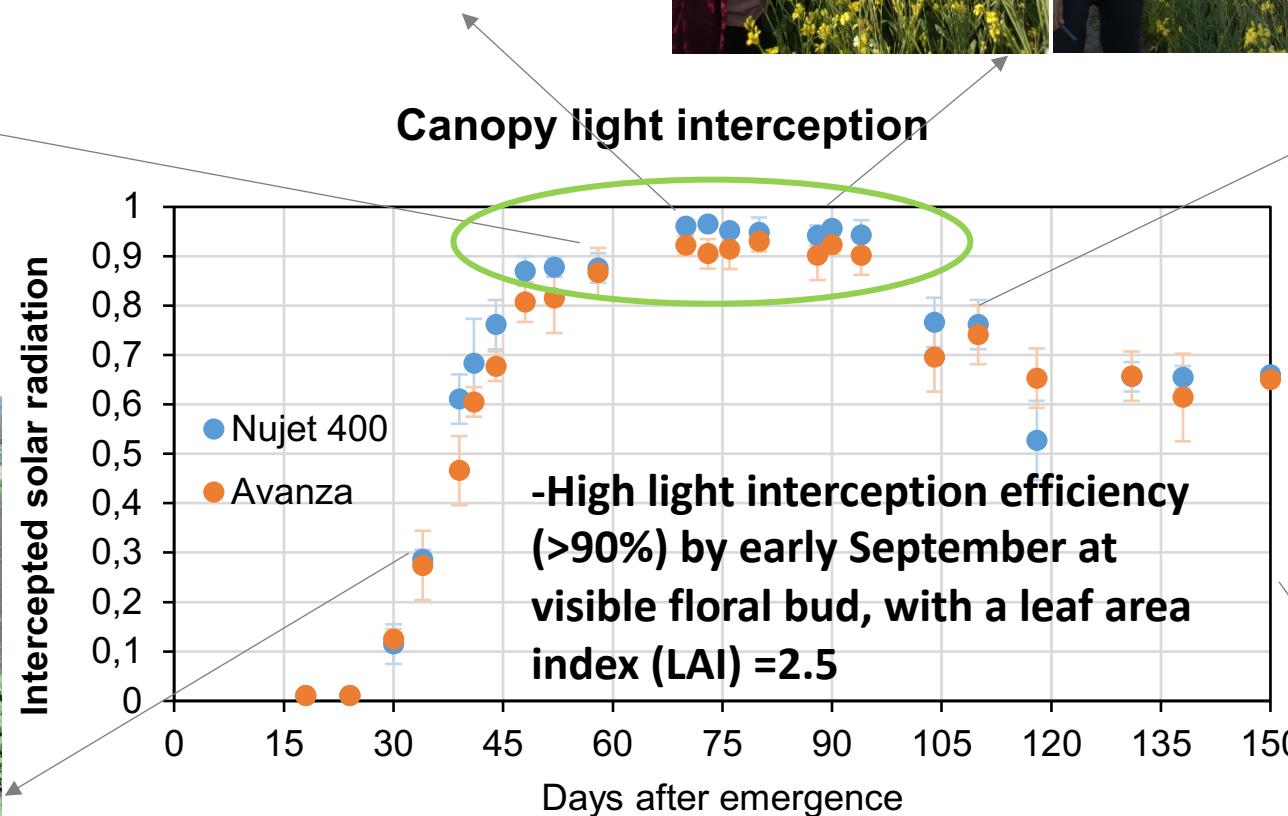
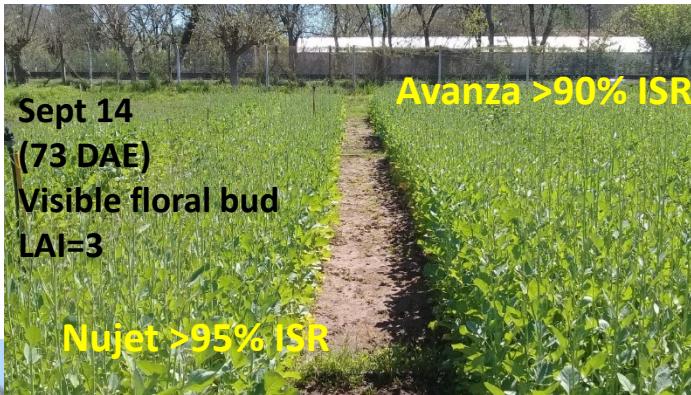
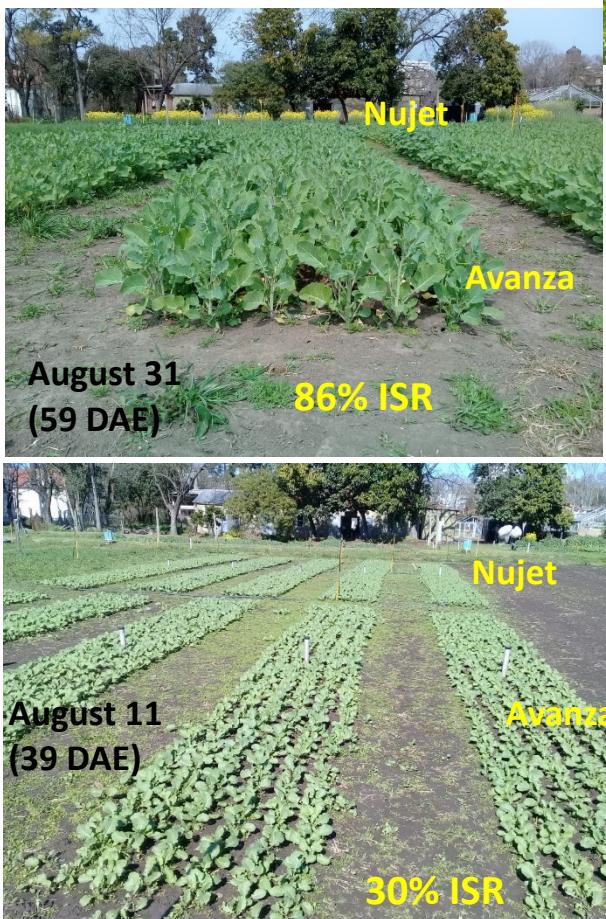
2021	Mean Temp $^{\circ}\text{C}$	Cum Rain mm	Cum Rad in MJ/m^2
June	12	11	190
July	12	57	265
August	13	45	357
Sept	16	146	332
Oct	19	23	549
Nov	22	140	604

- A few days with **low temperatures** (close to freezing) before V4
- Some days with **heat shock** ($>30^{\circ}\text{C}$) during grain filling
- Drier than the historical record (supplemental irrigation) but heavy rains in September (prior to Flowering) and at late November (prior to Maturity)

Cloudy periods in early September (prior to Flowering) and early November (grain filling)

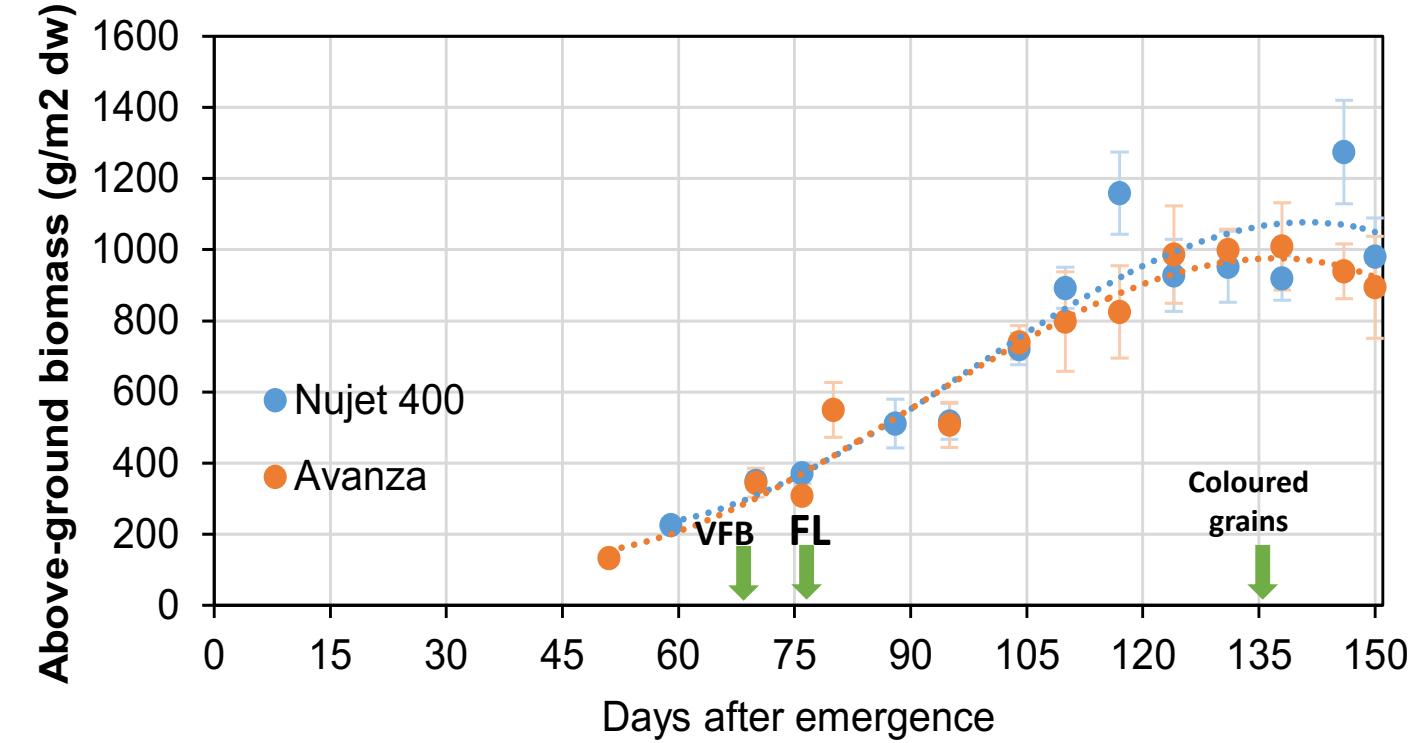
Canopy light capture

- Quick ground cover (from 30 to 60 DAE) in August
- Slightly higher light capture for Nujet 400



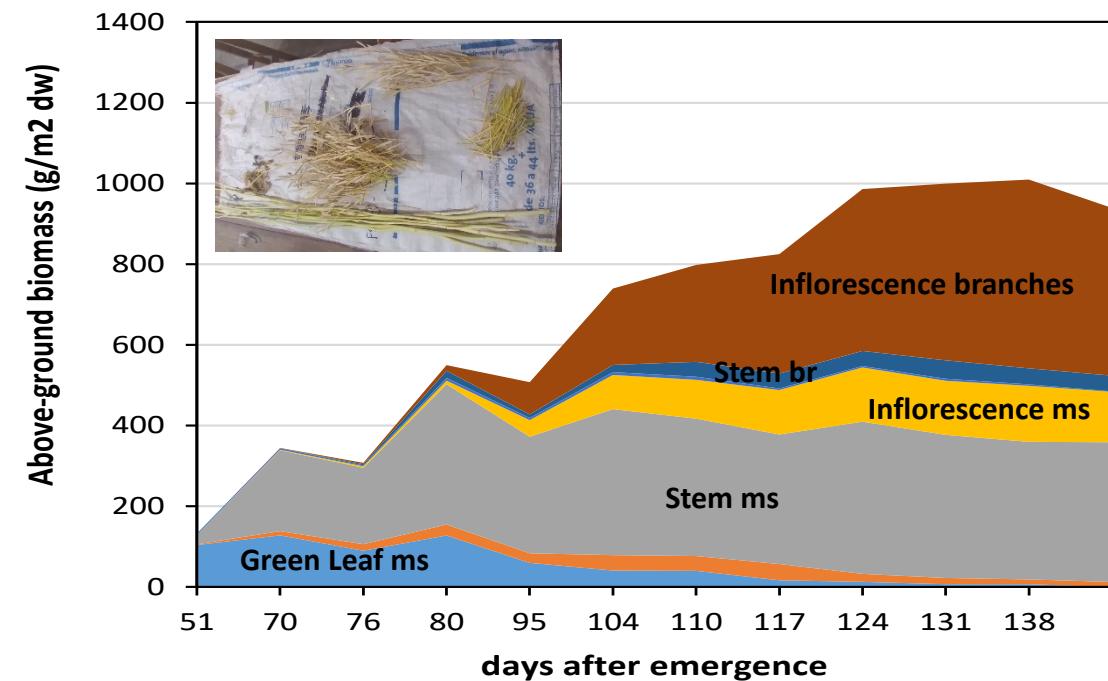
Above-ground biomass

Above-ground biomass



- Typical sigmoid pattern
- 2/3 of biomass grows after flowering
- Both genotypes reach similar biomass at harvest (p value=0.64)

Biomass allocation

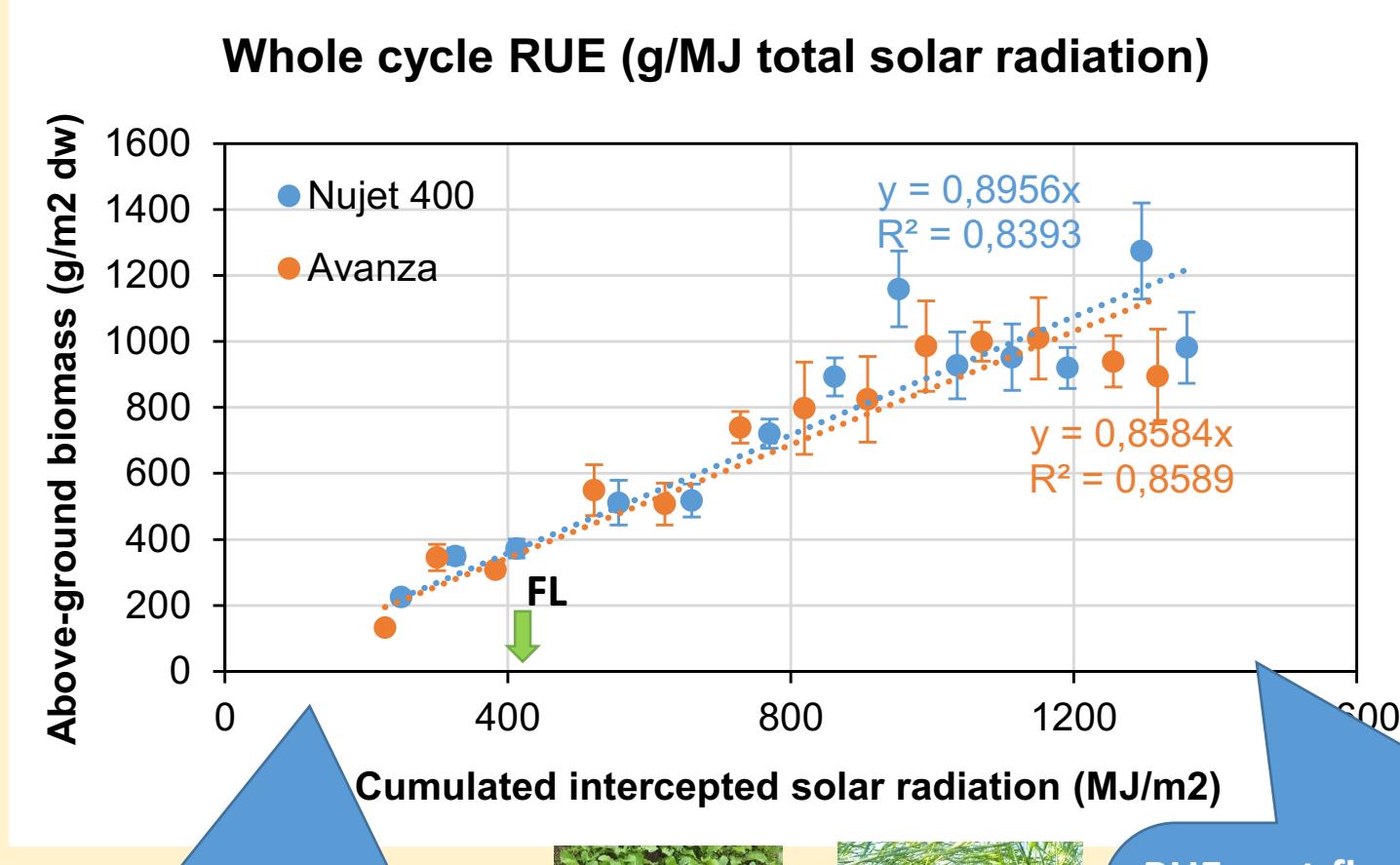


131-146 DAE	Nujet	Avanza
Stem	35 %	35 %
Inflorescence ms	15 %	13 %
Inflorescence br	45 %	45 %

At harvest:

- Most of biomass is in the branches (45%)
- Main stem retains 35% of the biomass

Radiation-use efficiency for the whole cycle



RUE pre-flowering (few data points)
0.87-0.95 g /MJ intercepted solar radiation
Lower value than canola pre-flowering (typically 1.35 g/MJ) and other C3 crops (1.2-1.7 g MJ)



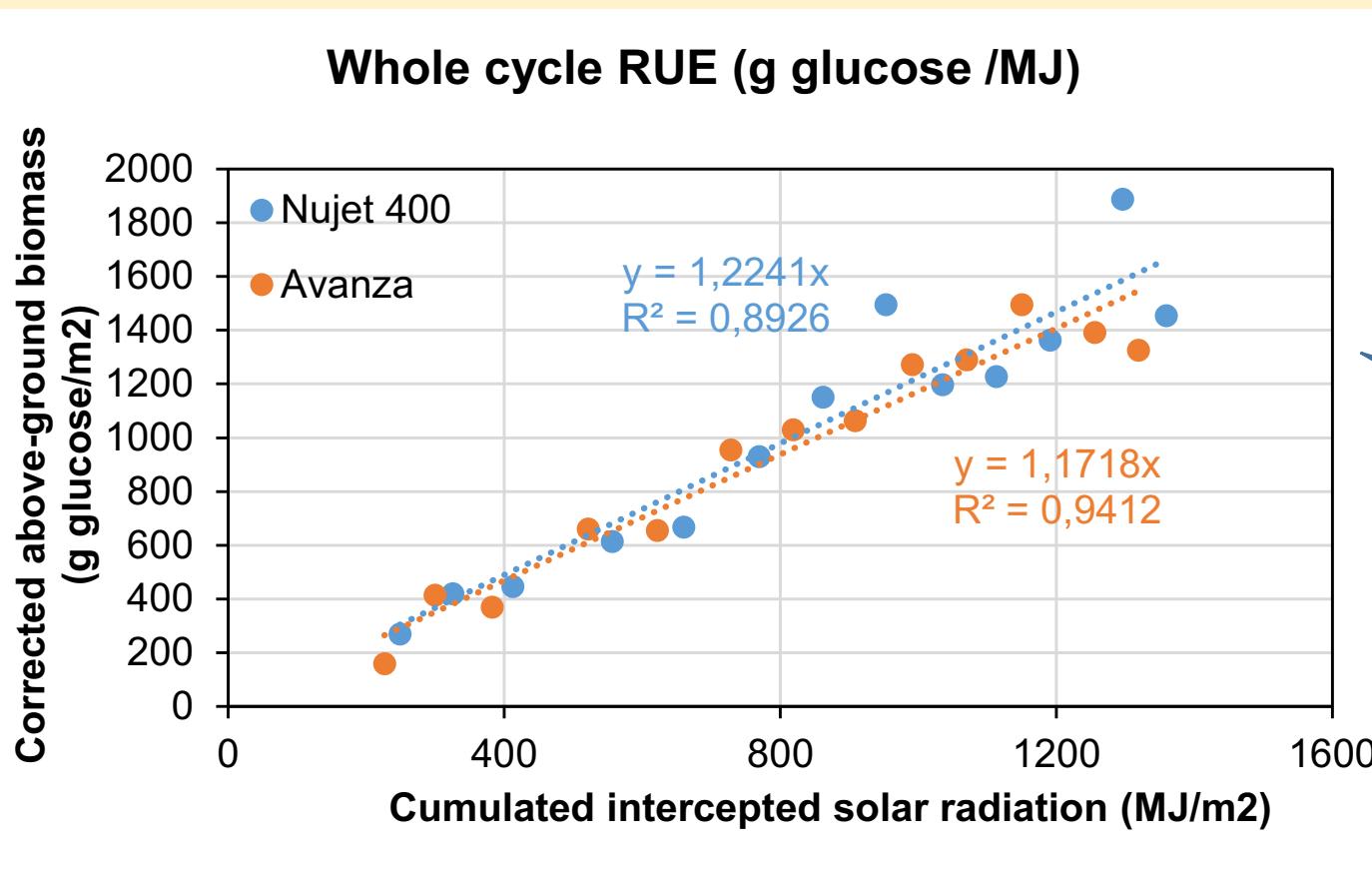
RUE post-flowering
0.85-0.89 g /MJ total intercepted solar radiation
A higher value than canola post-flowering (typically 0.4-0.75 g/MJ) possibly associated to -more open and lax inflorescences (better sunlight canopy distribution)
-lower HI in *carinata* (less expensive biomass)

For the whole cycle:
RUE: 0.85-0.90 g /MJ
(lower than canola, around 1 g/MJ
Kuai et al 2015)

RUE: 1.8-1.9 g biomass per MJ PAR intercepted

Radiation-use efficiency for corrected biomass

Assumptions: aerial biomass is mainly carbohydrates; from 90 days after emergence (stabilized stem growth) biomass considers 10% of lignin (Wassner et al 2020); and the last 3 measurements (from coloured grains) consider grain biomass (0.24 HI and oil and protein % measured). Grams of glucose equivalent per gram of compound are considered according to Penning de Vries et al (1983).



RUE = **1.2 g glucose/MJ** total solar radiation

RUE = **2.5 g glucose/MJ PAR**

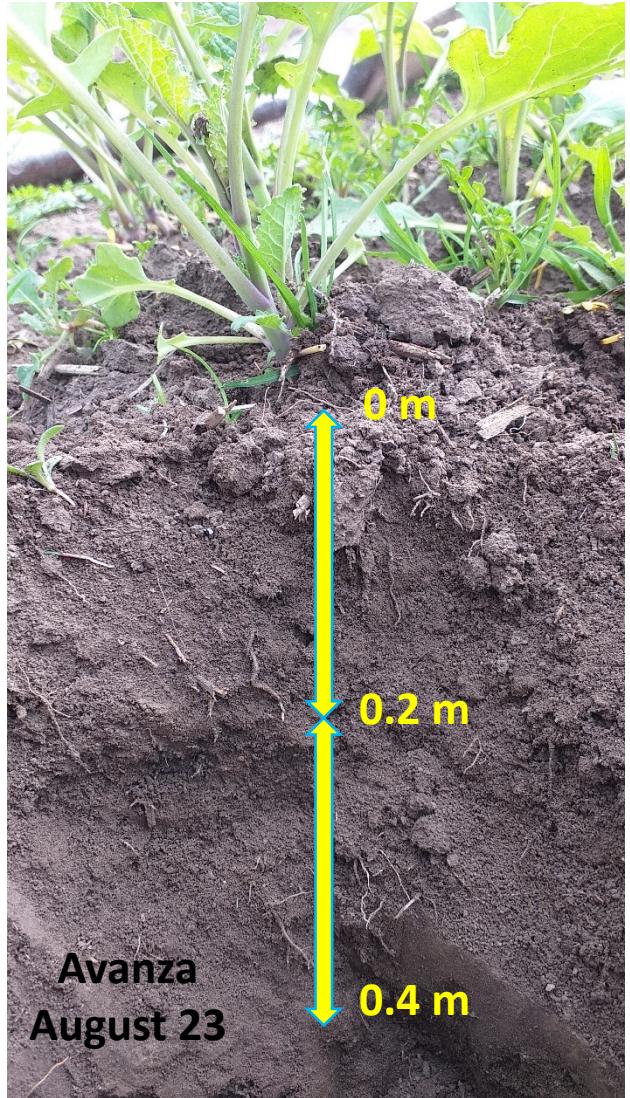
Table 1. Glucose required for synthesis of 1.000 g of a component, and concurrent respiration, expressed in CO₂ and in O₂.

Component	Glucose consumed (g)	CO ₂ produced (g)	O ₂ consumed (g)
Proteins (with NH ₃)	1.623	0.416	0.222
Proteins (with NO ₃)	2.475	1.666	0.431
Carbohydrates	1.211	0.123	0.099
Lipids	3.030	1.606	0.352
Lignin	2.119	0.576	0.189
Organic acids	0.906	-0.045	0.270

- Pre and post-flowering RUE are similar when energetic cost of biomass is taken into account
- RUE value 1.2 g /MJ falls in the range of C3 crops (1.2-1.7 g MJ)

Root sampling

Area = $0.2 \times 0.2 \text{ m}$ (row centered) $\times 0.4 \text{ m}$ total deep



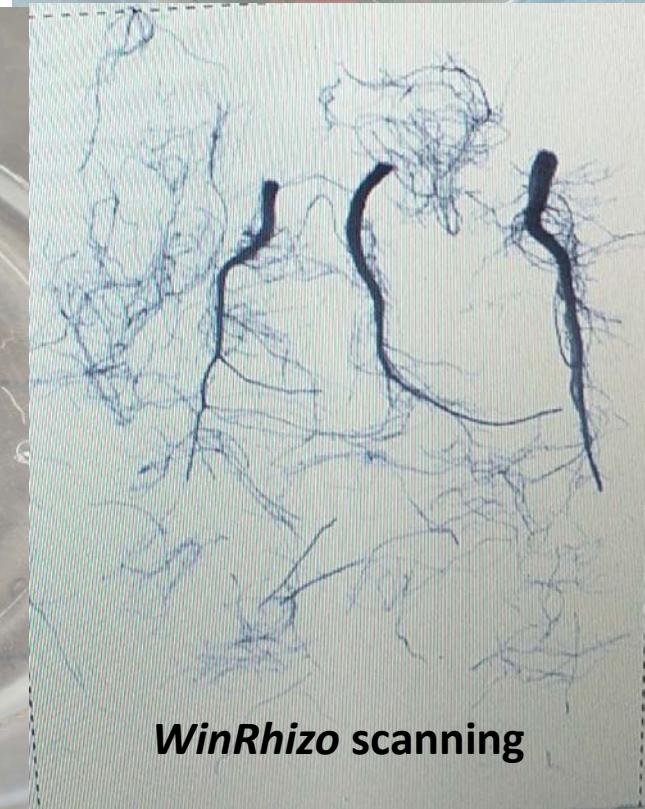
No roots below 0.4 m

Soil dispersion in
hypersaline solution
overnight
Root washing &
scanning

0-0.2 m deep

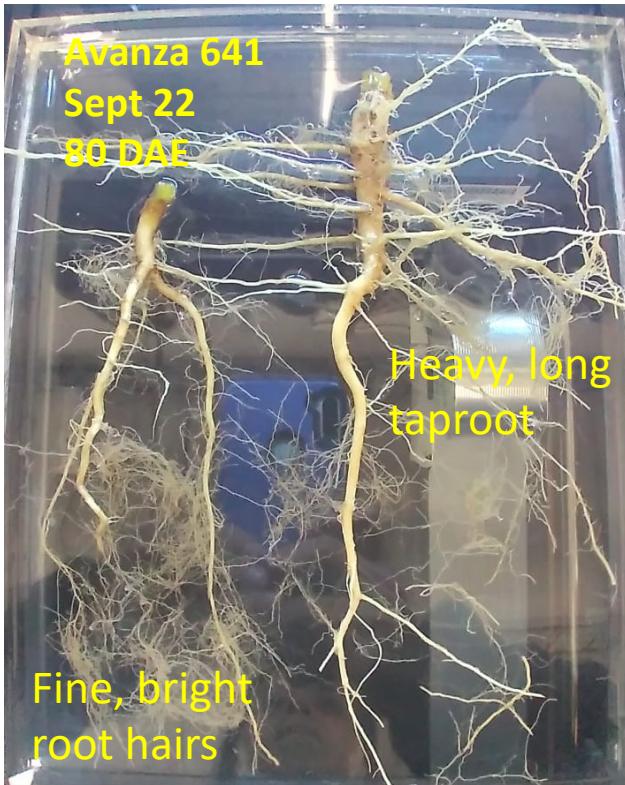


WinRhizo scanning

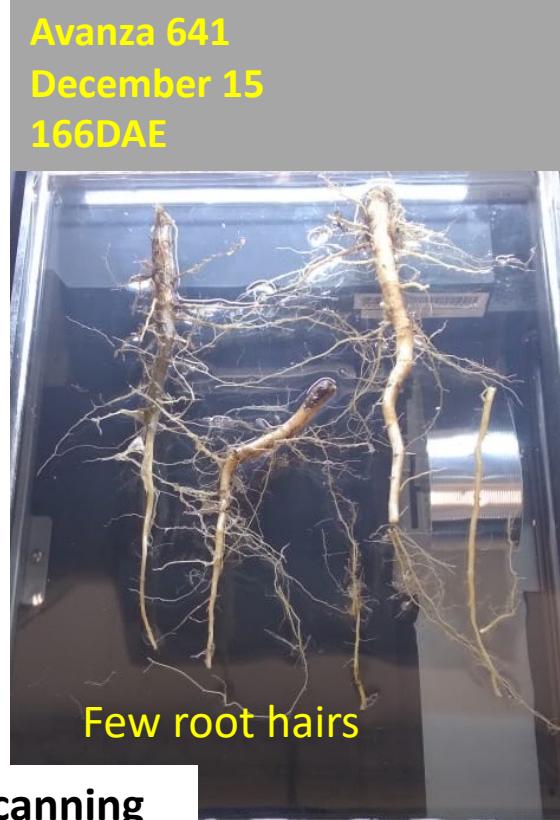
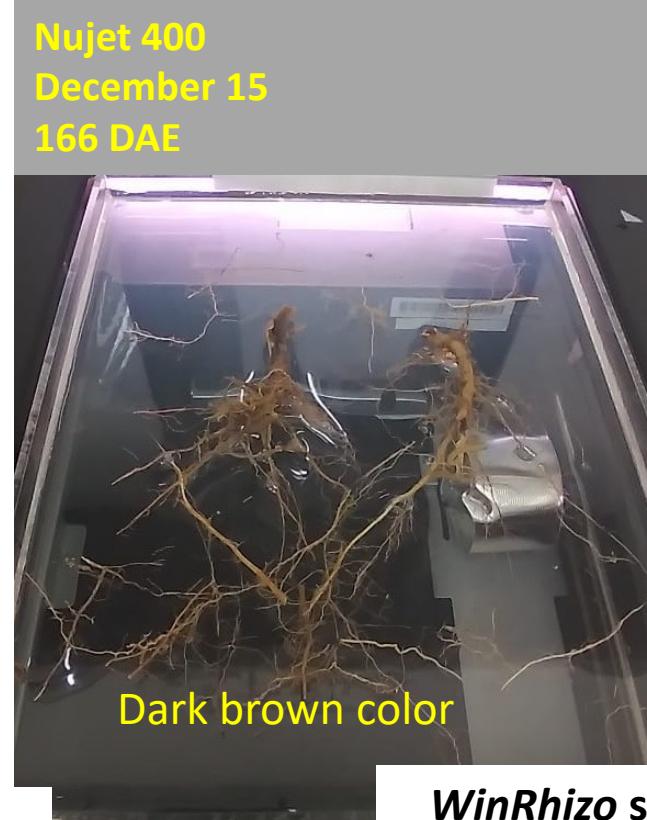


Root length

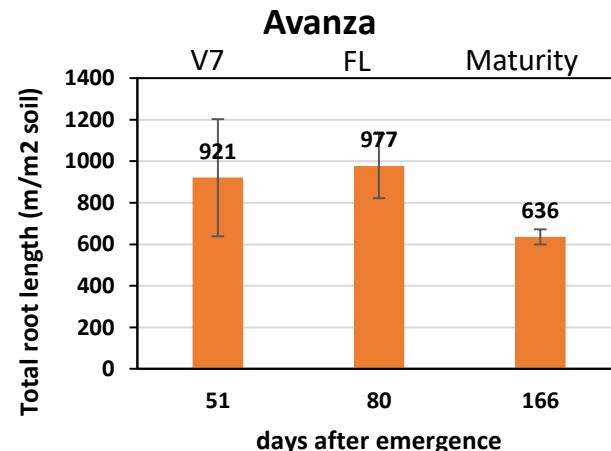
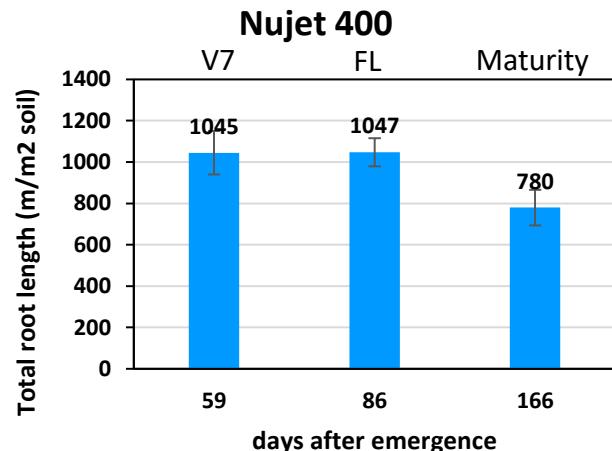
At flowering



After maturity



WinRhizo scanning

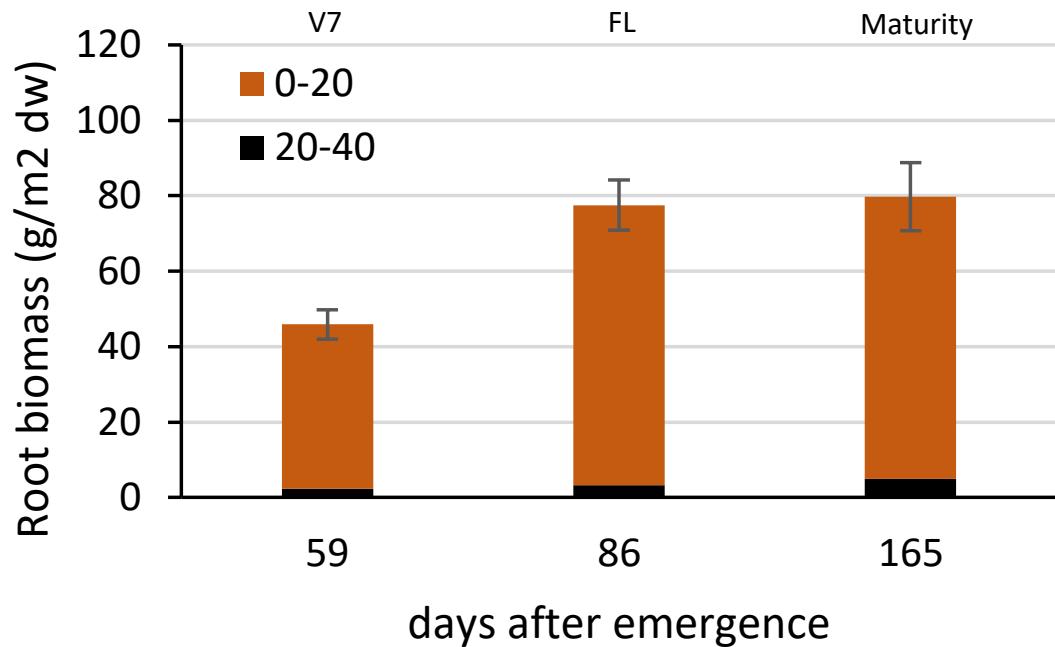


At flowering ≈ 1 kilometer roots per m² soil
(lower than 2-3 km/m² reported in canola) Zhang et al (2005) AJAR

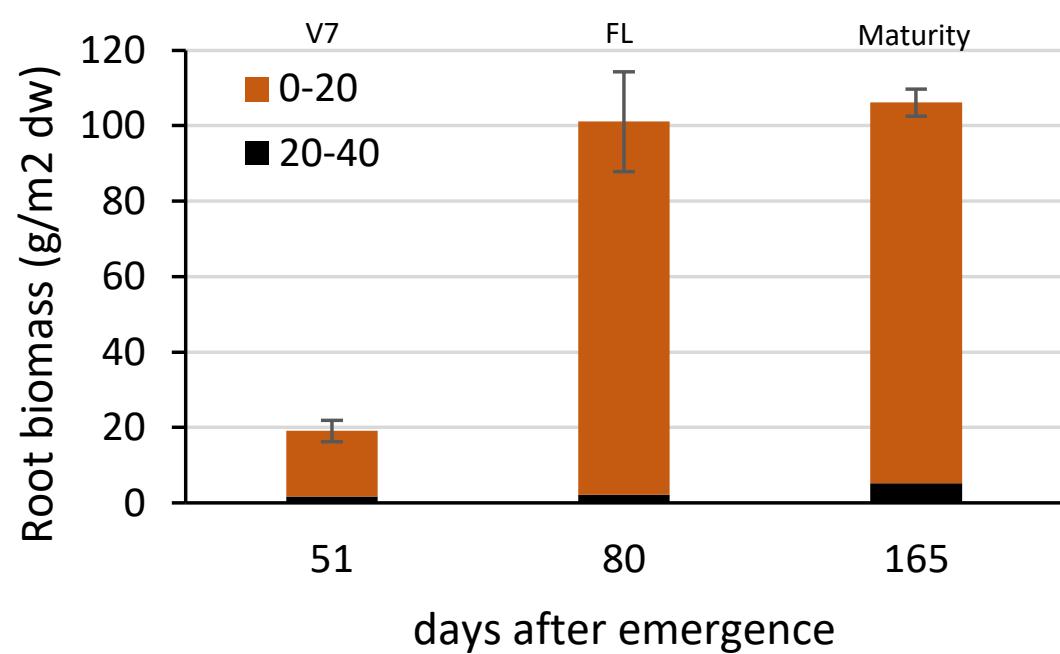
Reduction of root length post-flowering
After maturity ≈ 0.6-0.8 kilometer roots per m² soil

Root biomass

Nujet 400



Avanza



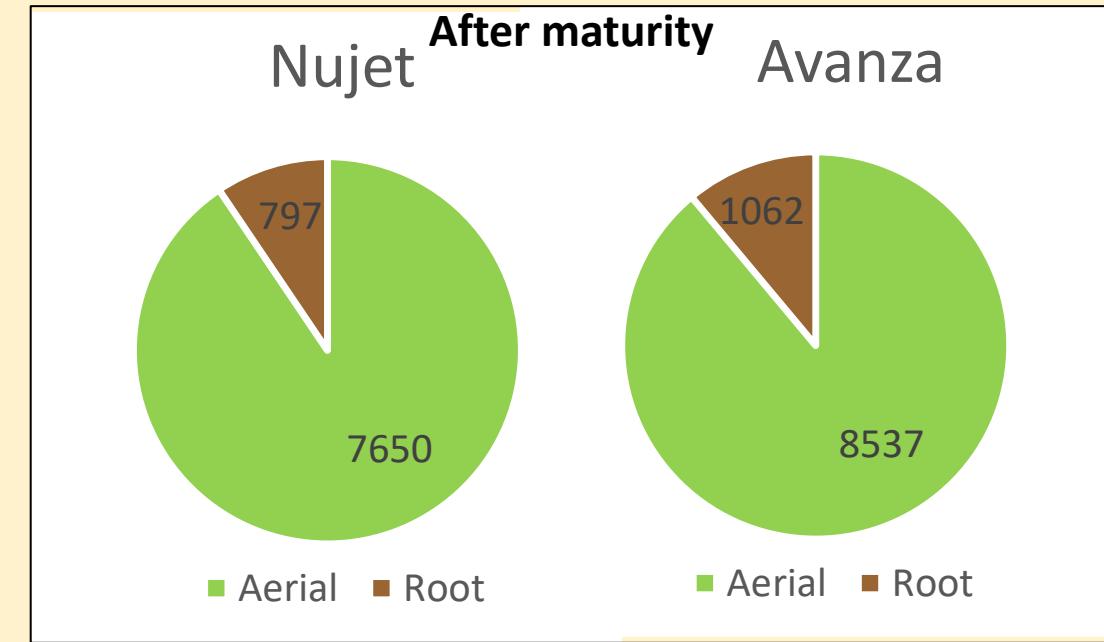
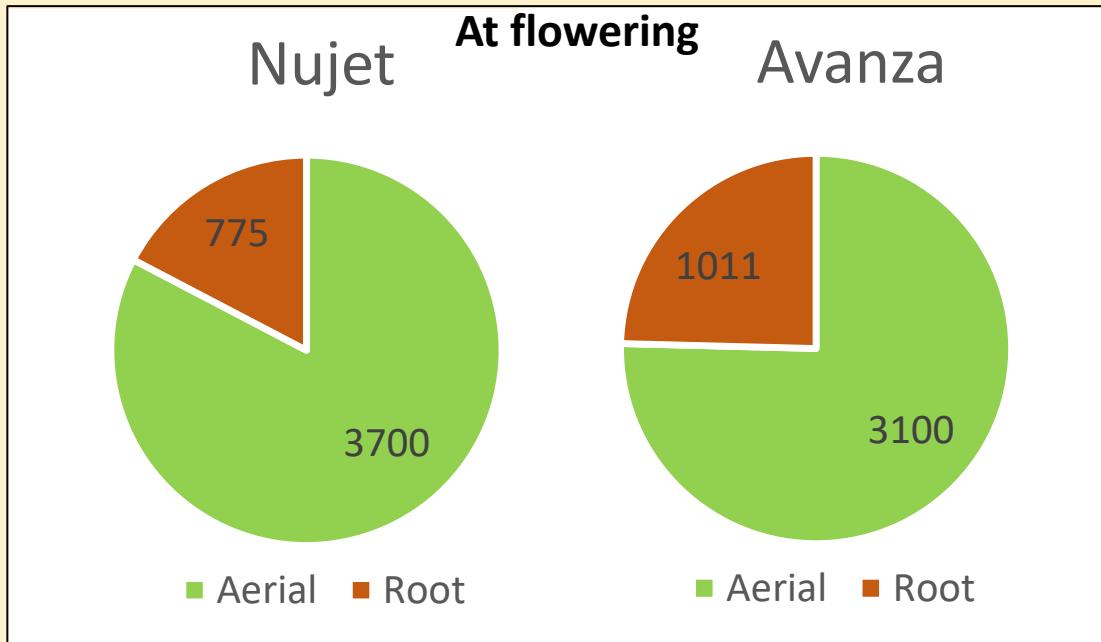
- Roots were mainly in the topsoil and did not deepen beyond 0.4 m (strong Bt clay horizon)
- At flowering \approx 800-1000 kg/ha of dry biomass allocated in roots (20-30% of aerial biomass)
- Root biomass did not increase post-flowering (but aerial biomass increase twice)

Total root weight similar to *B. carinata* in Uruguay (85-140 g/m²) Mazzilli & Ernst (2021)

and mustard (50-80 g/m²) Gan et al (2009) CJPS and within range for canola (100-160 g/m²) Zhang et al (2005) AJAR, Gan et al (2009) CJPS, Wu et al (2020) FPS

Shoot/root ratio

- Roots contribute 1 ton/ha more dry biomass to the cropping system
- Root biomass is 20-30% more than aerial biomass at flowering
- Root biomass is 10% more than aerial biomass at maturity

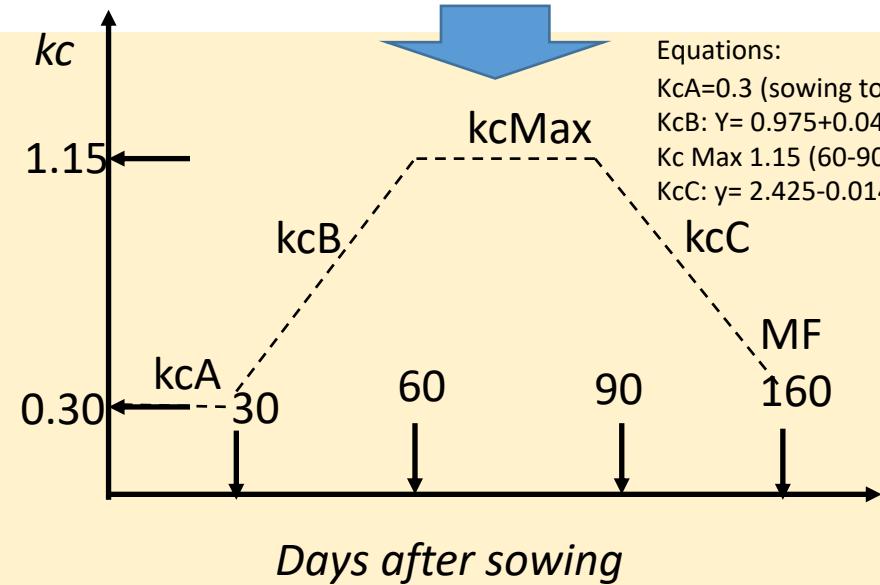
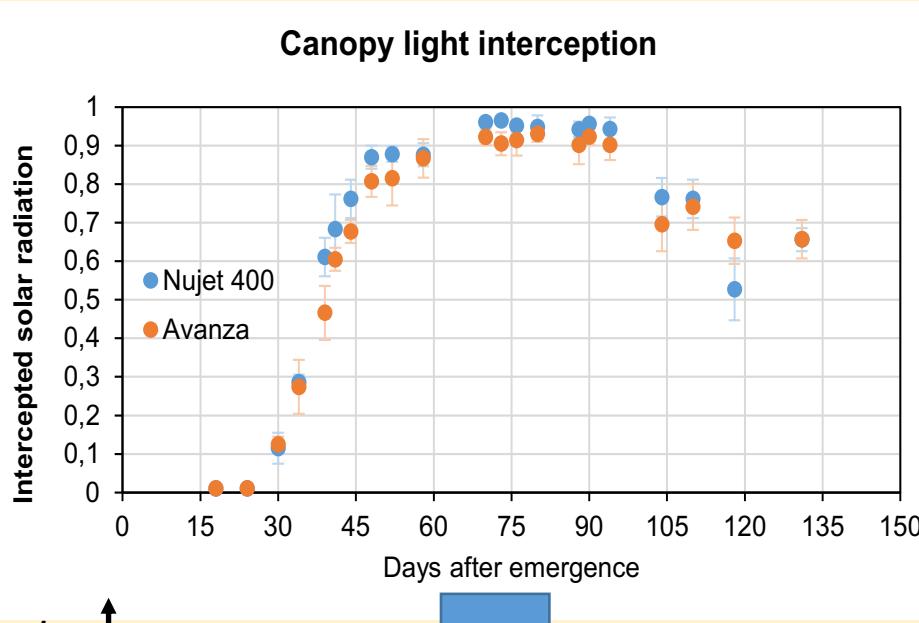


Total Biomass at Flowering	Nujet 400	Avanza 641
Aerial (Kg/ha DW)	3700 ± 280	3100 ± 180
Root (Kg/ha DW)	775 ± 60	1011 ± 135
Shoot/root ratio	4.7	3.0

Total Biomass (15 days after Maturity)	Nujet 400	Avanza 641
Aerial (Kg/ha DW)	7650 ± 1154	8537 ± 1190
Root (Kg/ha DW)	797 ± 97	1062 ± 37
Shoot/root ratio	9.6	8.0

Shoot/root ratio at harvest (8-10) is in the range of *B. carinata* in Uruguay (7.5-11) Mazzilli & Ernst (2021)

Water-use efficiency: Crop Evapotranspiration (ETc) estimation



$$ETc = ETo \times Kc$$

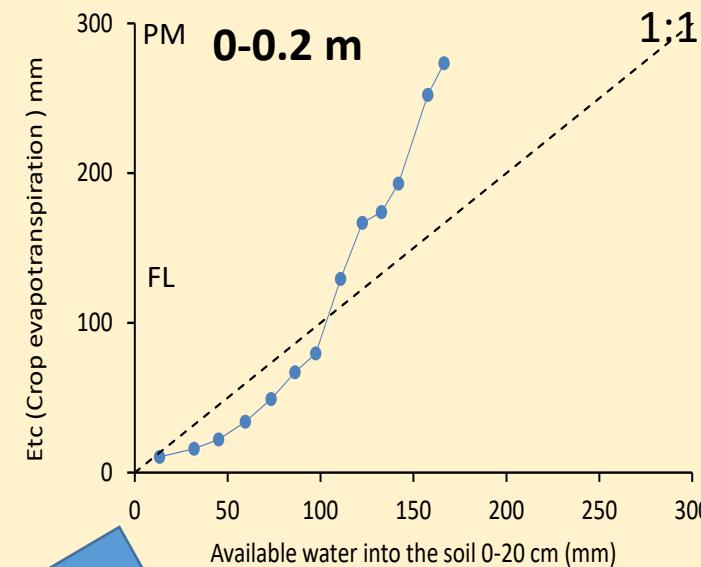
Potential Evapotranspiration (ETo): Penman FAO

Kc : crop coefficient based on dynamics of canopy light interception.

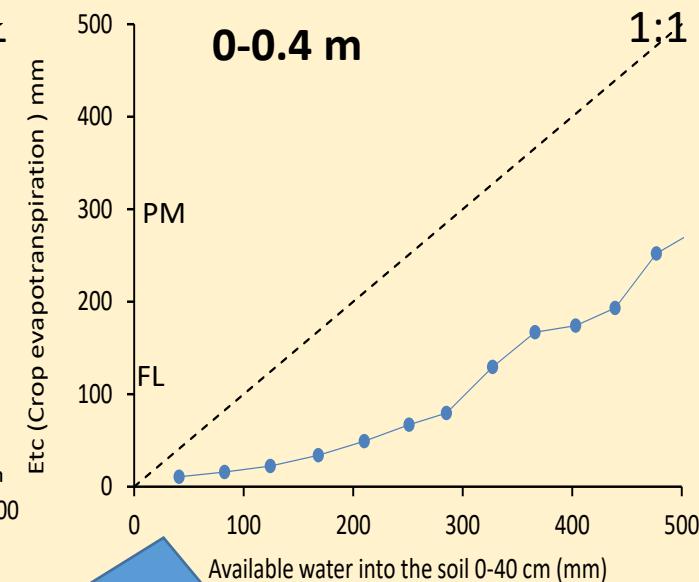
Assumptions: Minimum Kc : 0.30 (Andriani 2017); Maximum Kc : 1.15 (60-90 days after sowing)

Cumulative ETc (mm)	
Visible floral bud	100
First Flowering	120
Maturity	300

ETc vs soil water availability

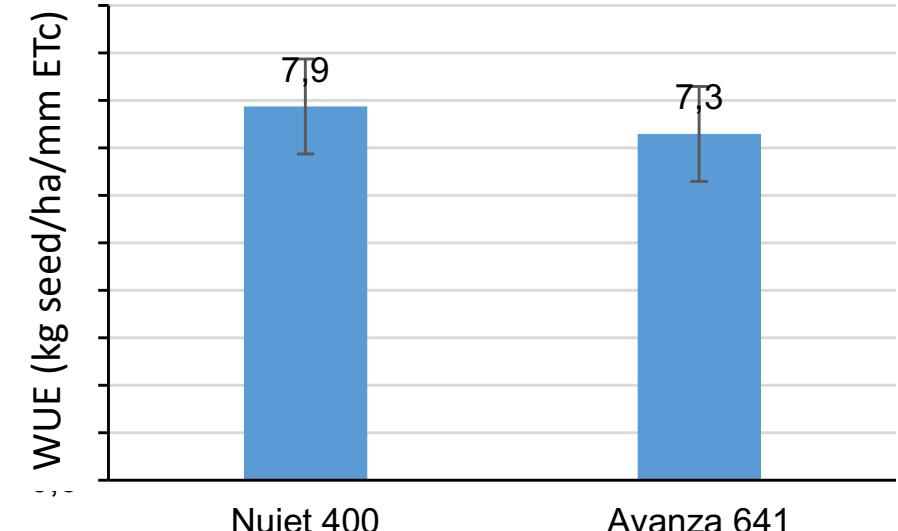
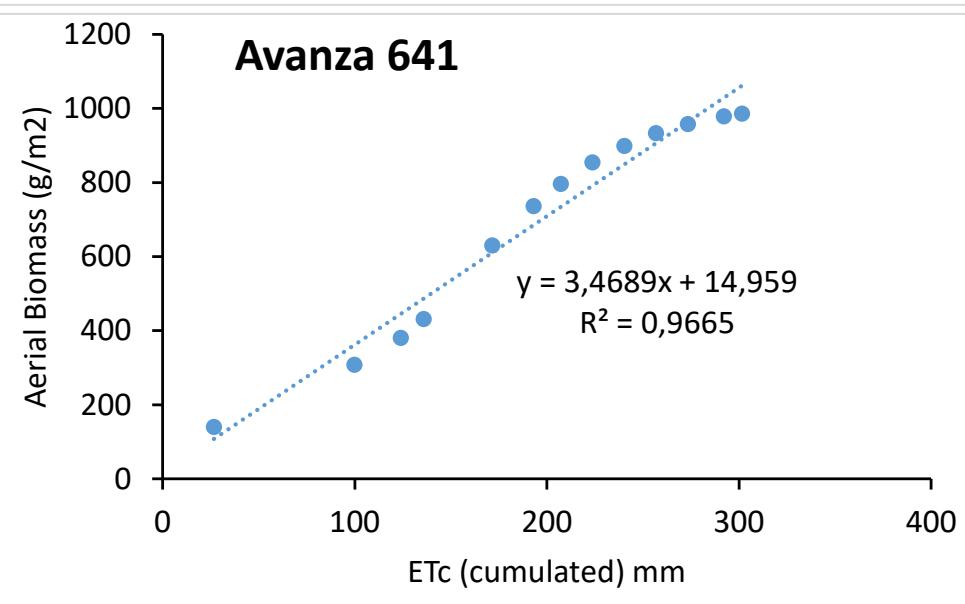
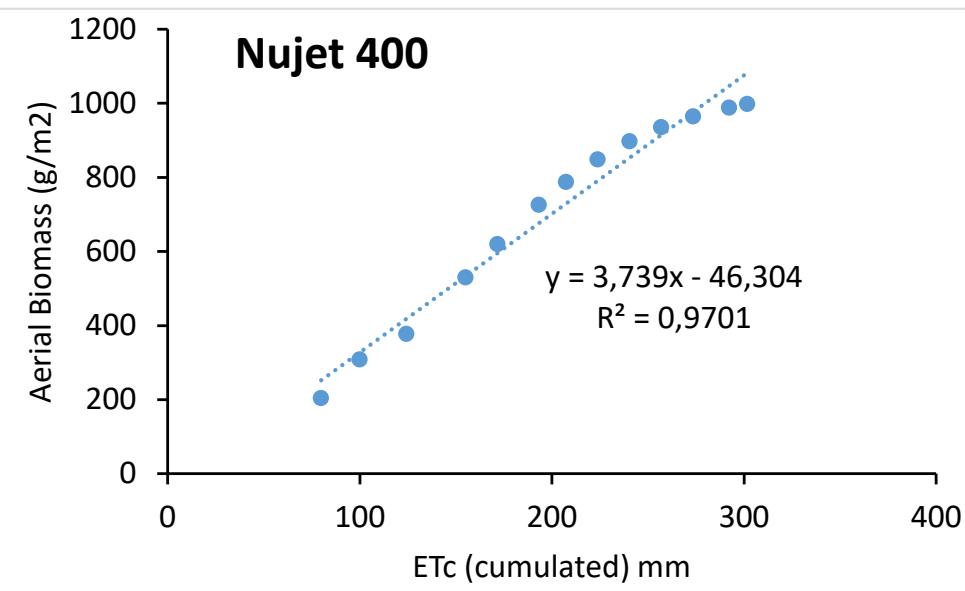


surface soil water was sufficient until flowering



deep soil water was consumed until maturity

Water-use efficiency: for aerial biomass and seed yield



WUE	Nujet 400	Avanza 641
WUE for aerial Biomass (kg biomass/ha/mm ETc)	37.4	34.7
WUE for seed yield (kg seed/ha/mm ETc)	7.9	7.3

WUE for seed yield: values in the range reported by Verma et al (2018) and Lal et al (2019) in *B. carinata* (5-10 kg/ha/mm) and Assefa et al (2018) and Kirkegaard et al (2021) in canola (7-15 kg/ha/mm)

Crop harvest

3 m (0.6 m^2) from central rows were hand-harvested

November 30, 2021 (150 days after emergence; 160 days after sowing)



Nujet 400

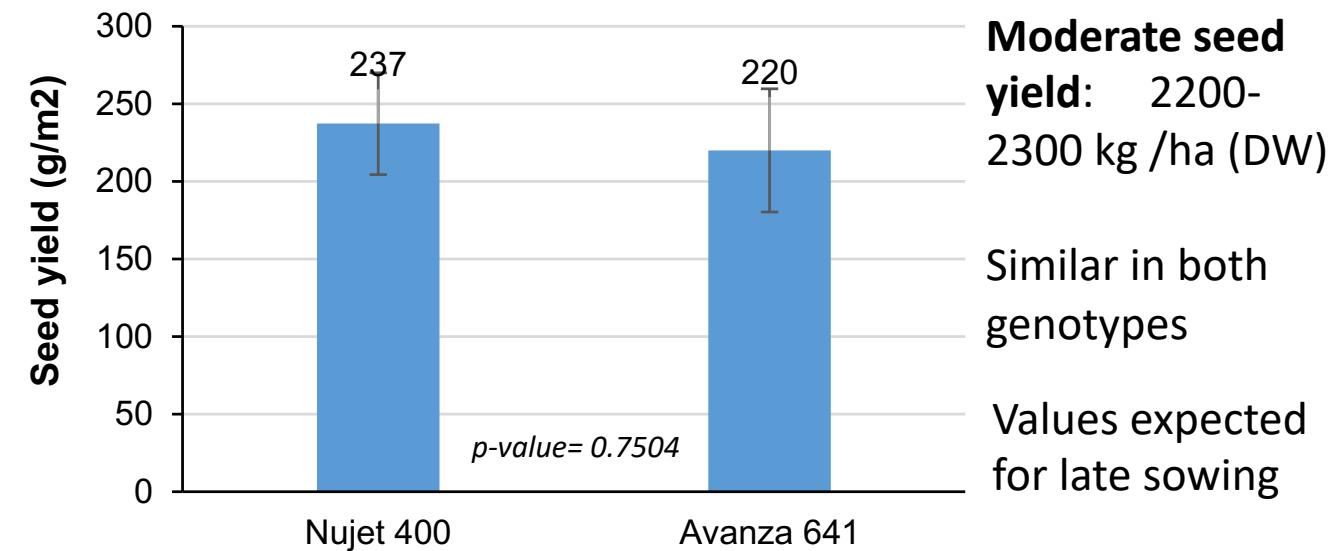


Avanza 641

There was not pod shattering!

Canopy structure	Nujet 400	Avanza 641	p-value
Plant height (cm)	150 ± 3.6	141 ± 3.2	0.0890
Main raceme length (cm)	31 ± 1.2	29 ± 0.5	0.0822
Height to the first siliques (cm)	108 ± 2.6	89 ± 3.0	0.0011
Primary branches (#/pl)	5.7 ± 0.4	6.9 ± 0.3	0.0252
Pods from the main raceme (#/pl)	16 ± 0.5	12 ± 0.4	0.0008

Nujet 400 had significantly more pods on the main raceme, less branching, and the first pods were located taller in the canopy

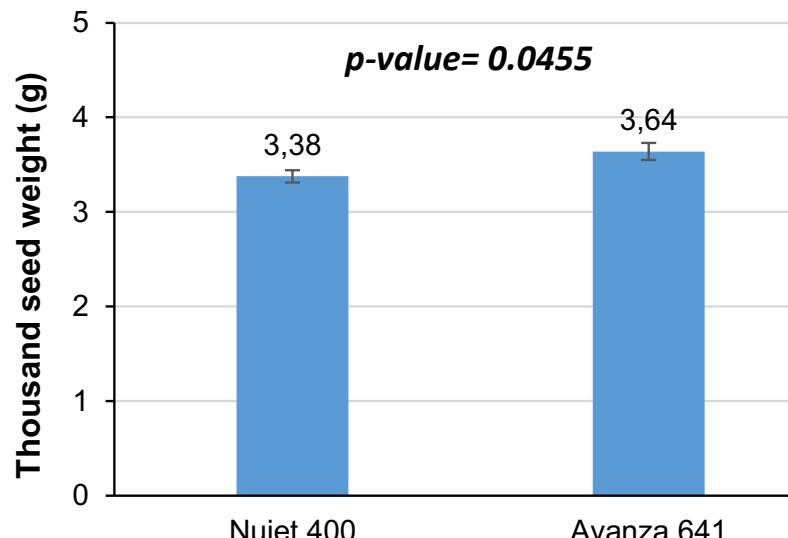
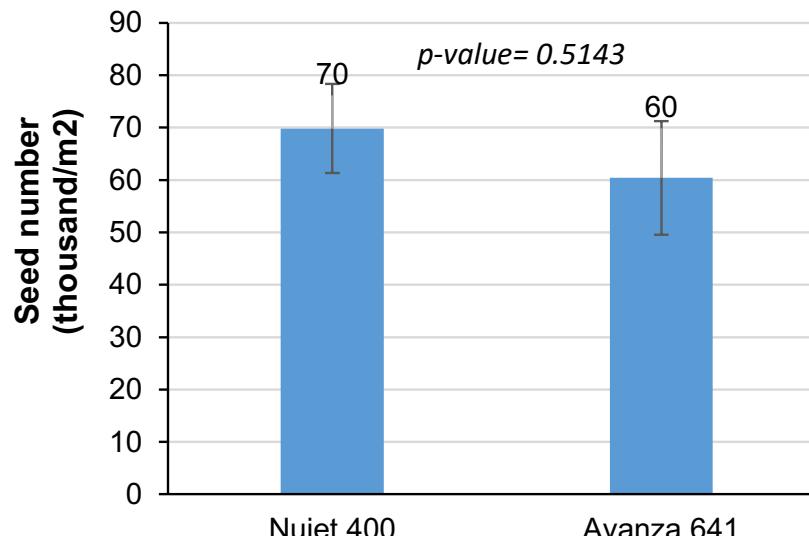


Moderate seed yield: 2200-2300 kg /ha (DW)

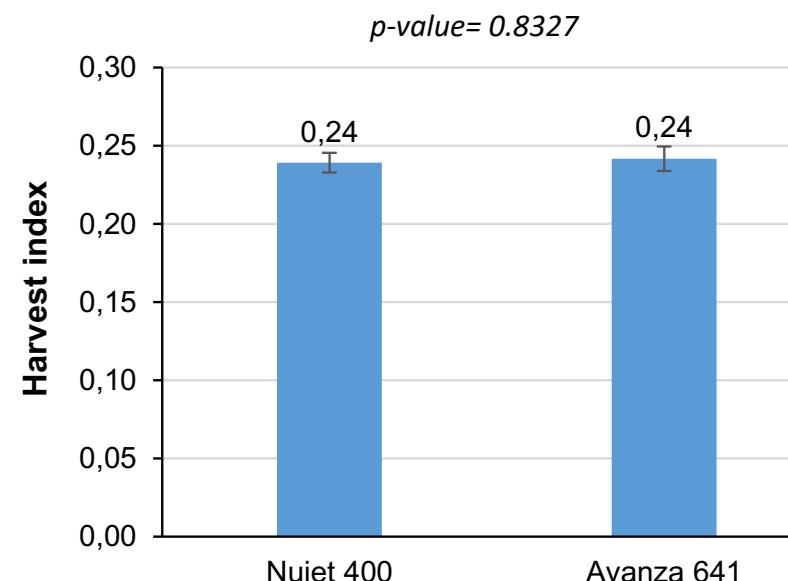
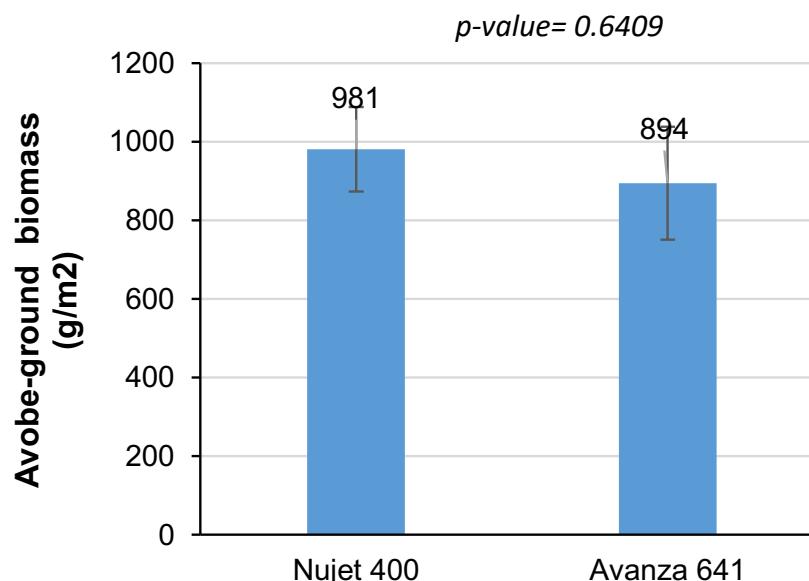
Similar in both genotypes

Values expected for late sowing

Seed yield components



Avanza 641 had significantly heavier seeds than Nujet 400

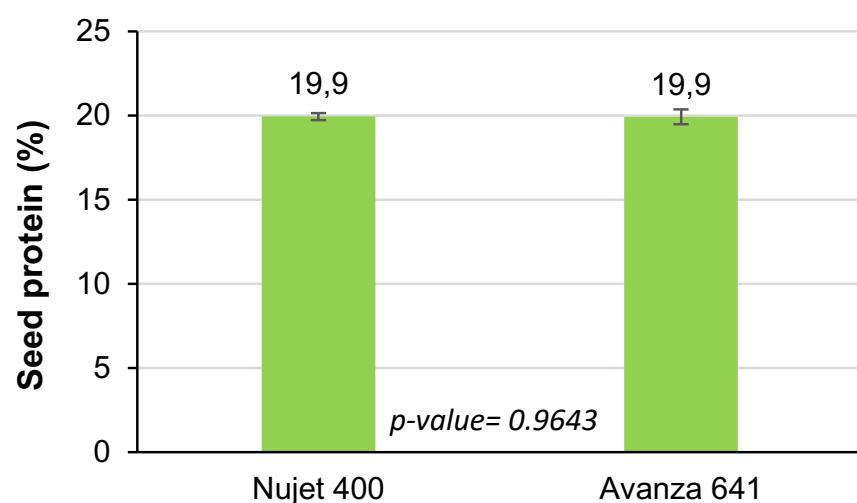
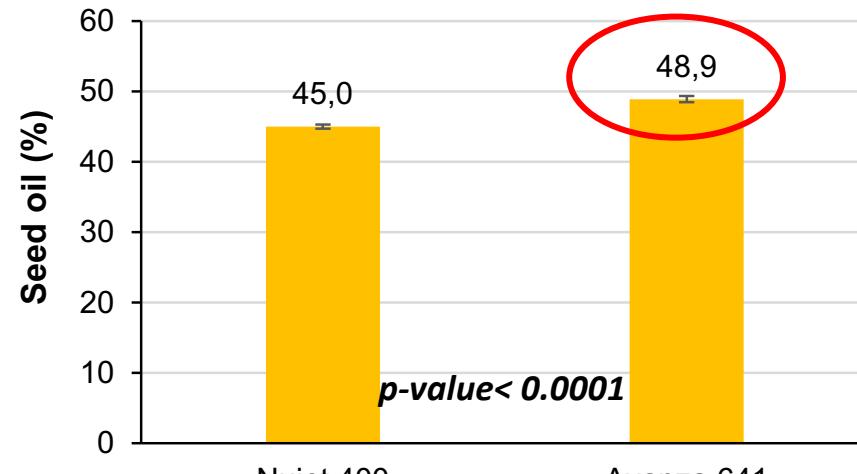


Harvest index (0.24) is in the lower range of *B. carinata* reported in USA (0.28-0.37) and Uruguay (0.23-0.34)

Seepaul et al. (2021); Mazzilli & Ernst (2020)

Seed composition

Oil by Soxhlet, Protein by Kjeldhal ($N \times 6.25$ protein) both in DW



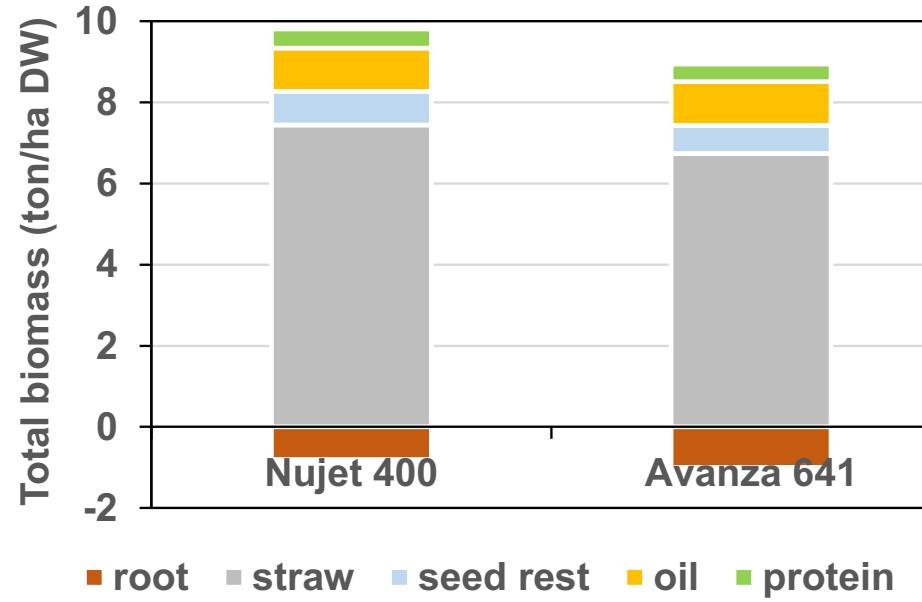
Seed composition similar to canola in Buenos Aires (37-51% oil; 16-24% protein) Rondanini et al. (2017)



Protein % in defatted meal:
36.3% Nujet,
39% Avanza,
 $p=0.0014$

Avanza 641 has more seed oil, but identical protein than Nujet 400
Oil % are very high compared to 39.7% reported in SE of USA (Seepaul et al 2021) and 42% in India (Lal et al 2019). Protein % is less than 22-31% reported in USA and India

B. carinata productivity



Average oil yield (**1 ton oil/ha**) and protein yield (**0.45 ton protein/ha**) leaving residual biomass (**7 ton straw/ha + 1 ton roots/ha**) for both genotypes

Preliminary conclusions

Brassica carinata sowed late in June in the Pampas, irrigated and fertilized, efficiently used solar light and water to produce biomass.

It had moderate seed yield with low harvest index but valuable seed composition

At harvest, it contributed 7 ton/ha of stubble + 1 ton/ha of roots to the farming system

Thanks!



Crop Ecophysiology
@grupotrigofauba/