Technical agreement NUSEED-FAUBA 2021

Final Report

March 2022

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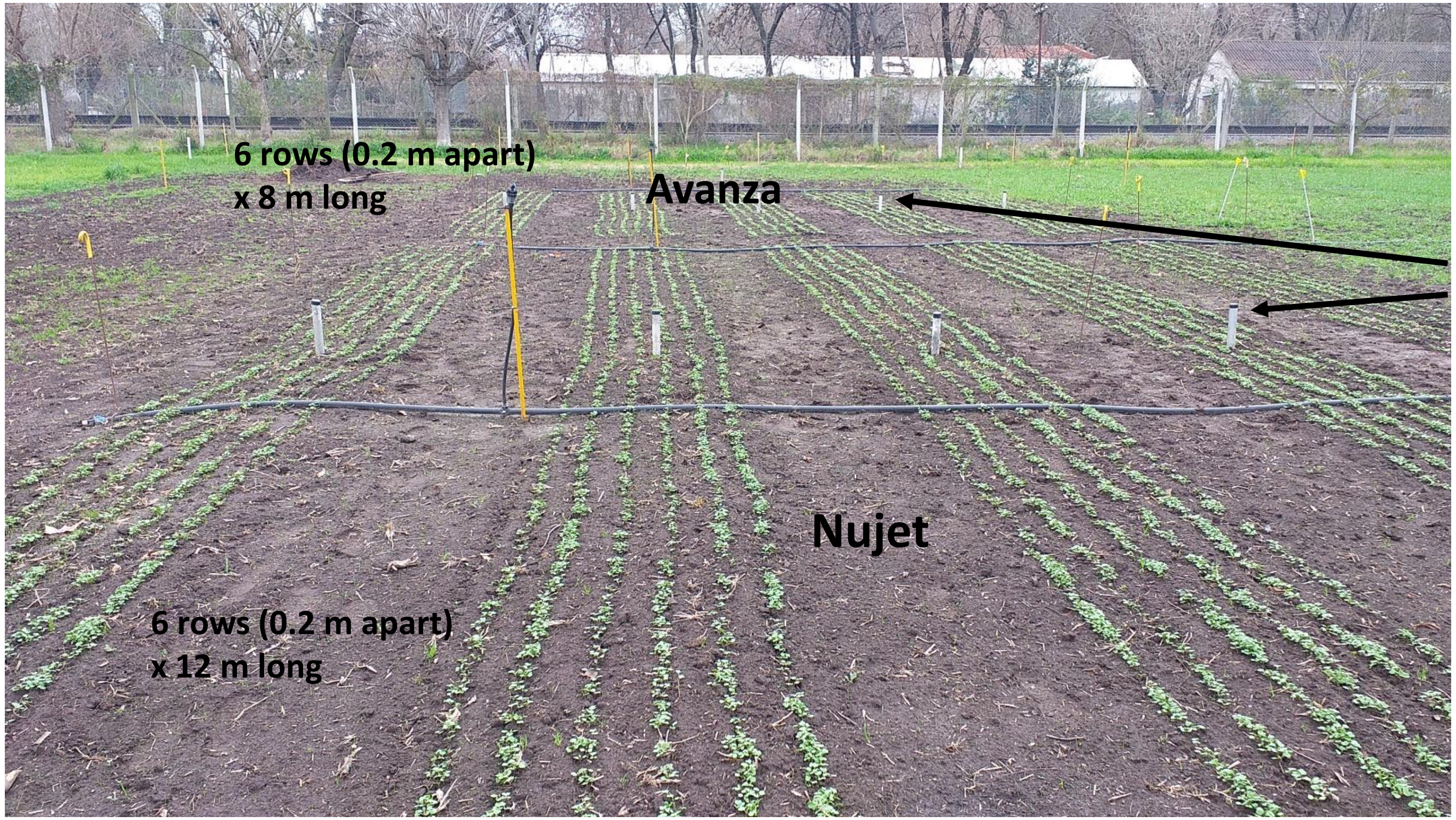
Section A

Brassica carinata biomass

Experimental Approach 2021

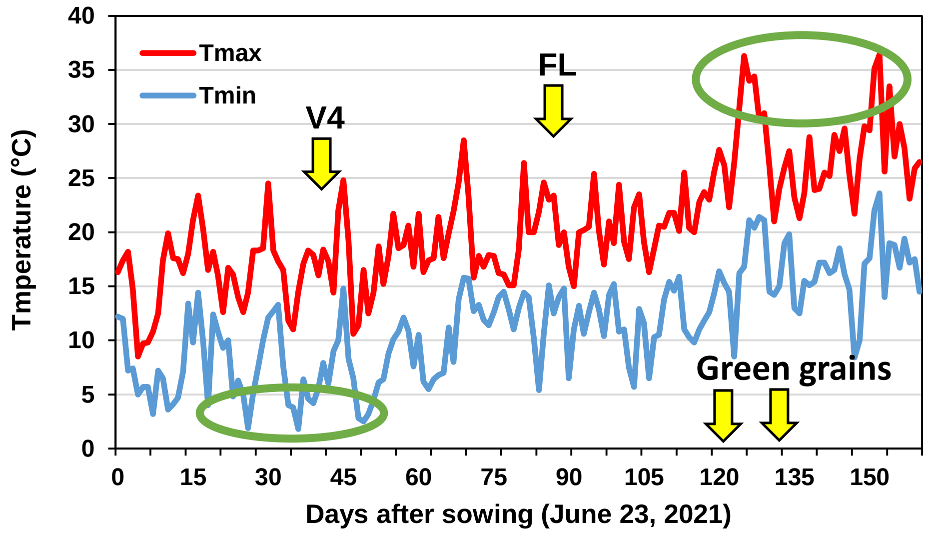
Experiments at the School of Agriculture, University of Buenos Aires (34°36’S 58°26’W)
Soil: Typical Argiudoll with a strong clayey horizon (Bt) at 40 cm depth

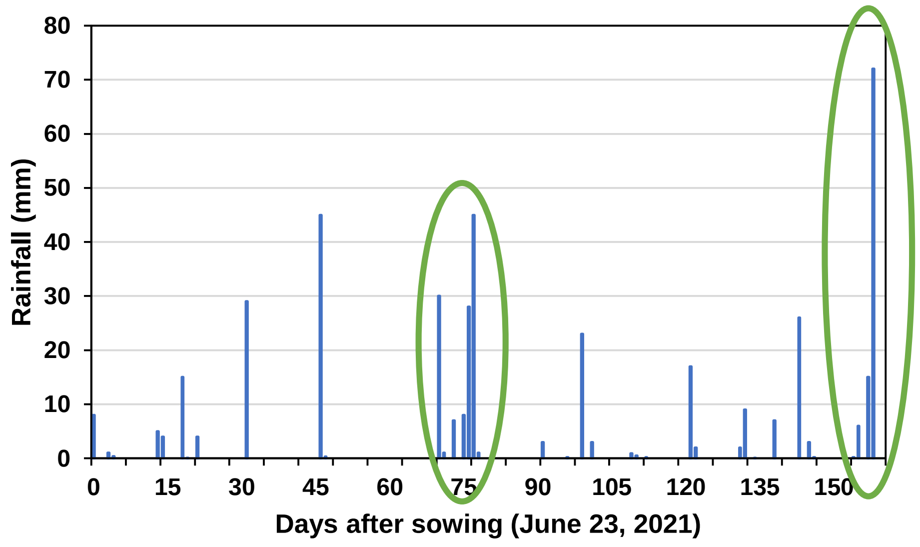
Nujet 400 (hybrid) and Avanza (OP variety) with 5 replicates **<u>Sowing date: June 23, 2021</u>** Planting rate: 100 plants/m2
Husbandry: irrigated and fertilized (up to 100 kg N available/ha) and preventive fungicide in VE and V6

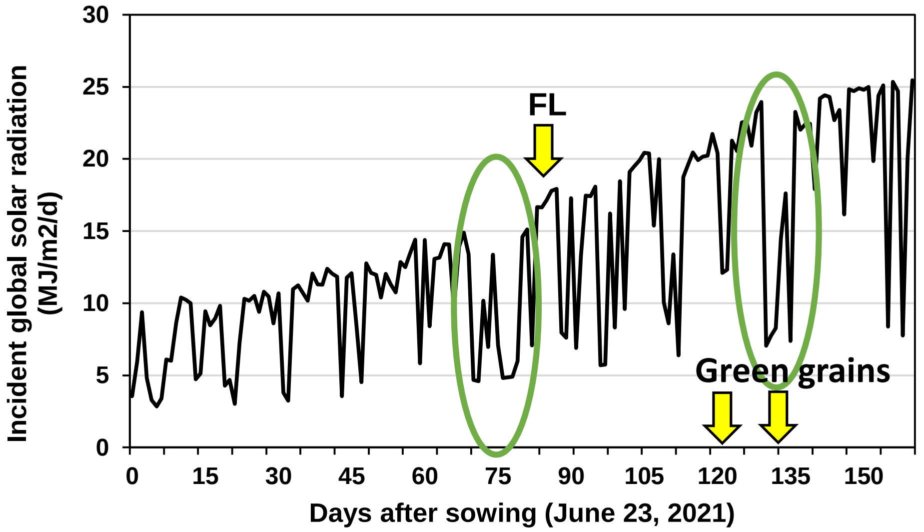


1.2 m deep probe tubes (water measurements)

Meteorological conditions







2021	Mean Temp °C	Cum Rain mm	Cum Rad MJ/m2
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 very heat shock (>30°C) during grain filling

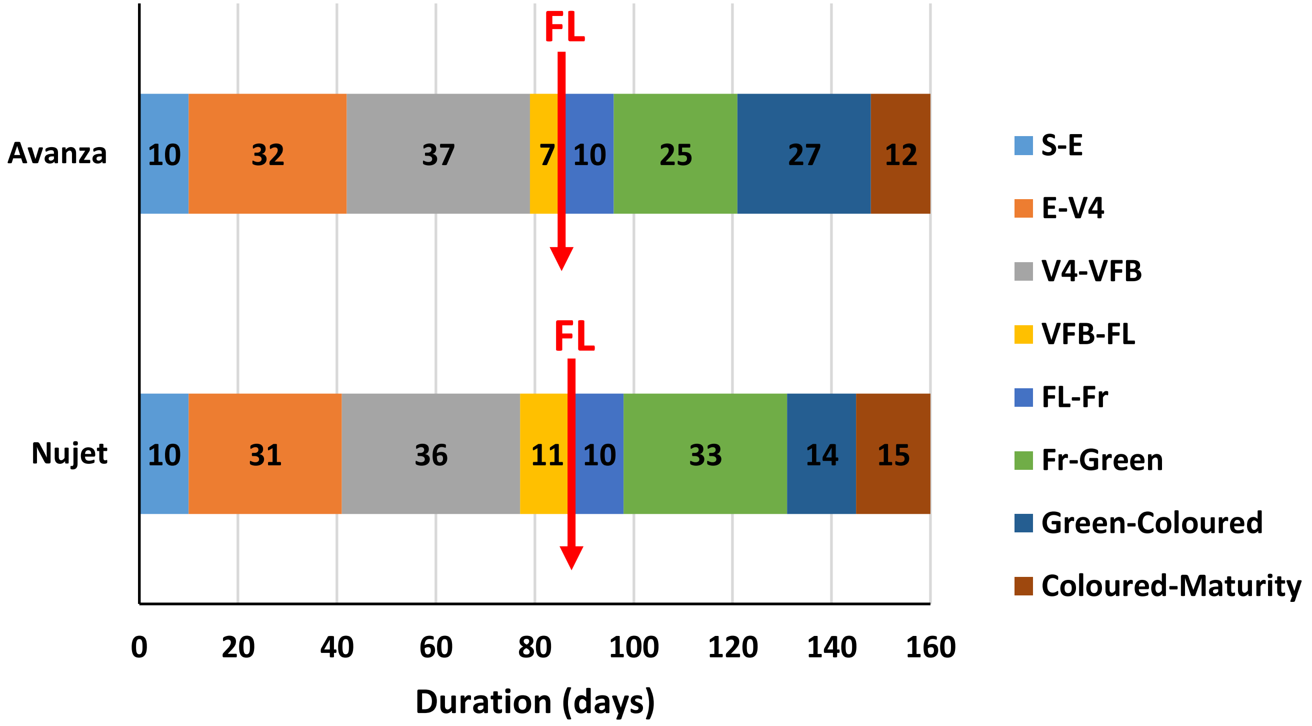
'La Niña' phase

-Drier than the historical record (supplemental irrigation) with heavy rains at late November (prior to Maturity)

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

Crop phenology

-Similar crop phenology in both genotypes
-Beginning of flowering in mid-September
-Maturity in late November



DAS: days after sowing

<u>Sowing date: June, 23</u>
Emergence: July, 3 *(10 DAS)*

Visible floral bud (VFB):
Nujet: Sept, 8 *(77 DAS)*
Avanza: Sept, 10 *(79 DAS)*

<u>First flowering</u> (FL):
Nujet: Sept, 19 *(88 DAS)*
Avanza: Sept, 17 *(86 DAS)*

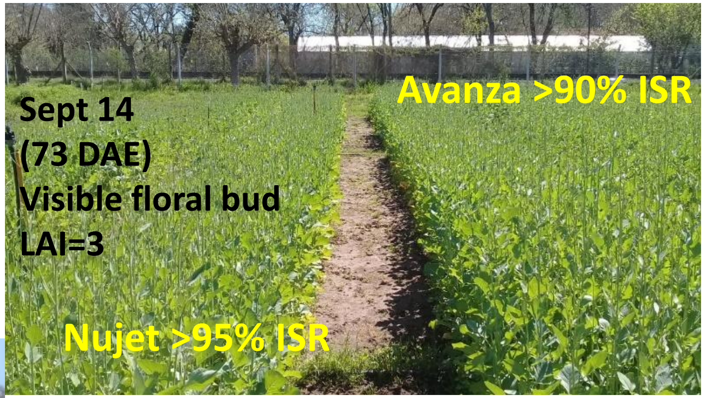
Maturity:
Nujet: Nov, 30 *(160 DAS)*
Avanza: Nov, 30 *(160 DAS)*

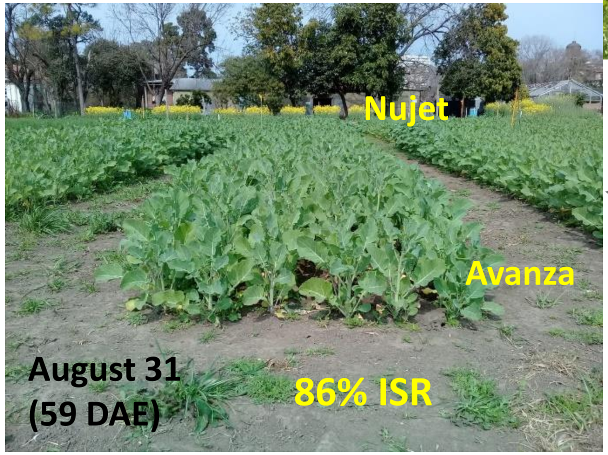
Days from <u>**sowing to flowering**</u>: **88 days Nujet, 86 days Avanza**
<u>Whole crop cycle</u>: 160 days after sowing (around 55% of cycle for pre-flowering and 45% for post-flowering)

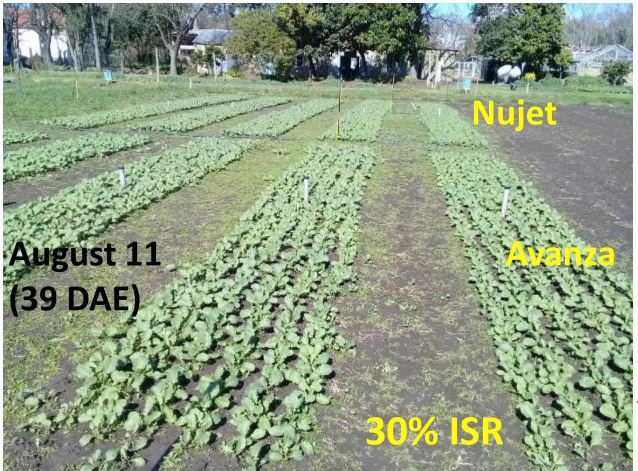
Canopy light capture

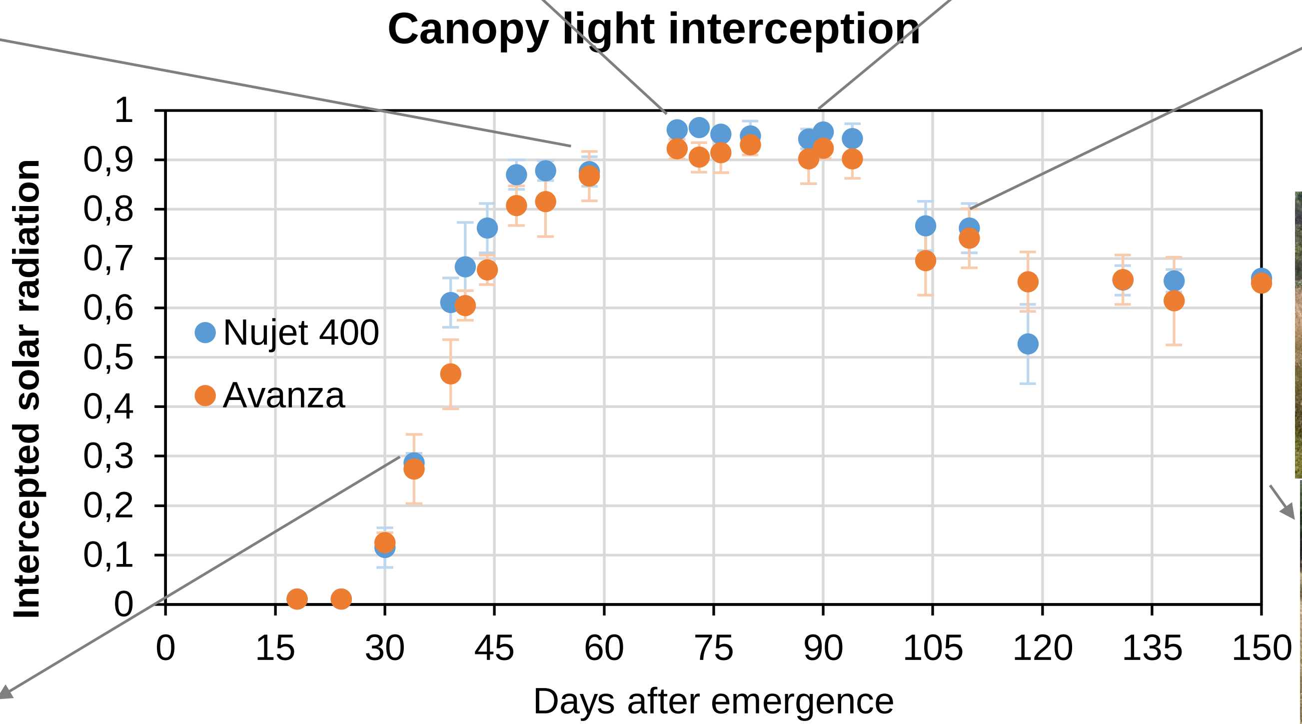
-High light interception efficiency (>90%) by early September at visible floral bud (VFB)

-Slightly higher light capture on Nujet
-Quick soil coverage (from 30 to 60 DAE) in August



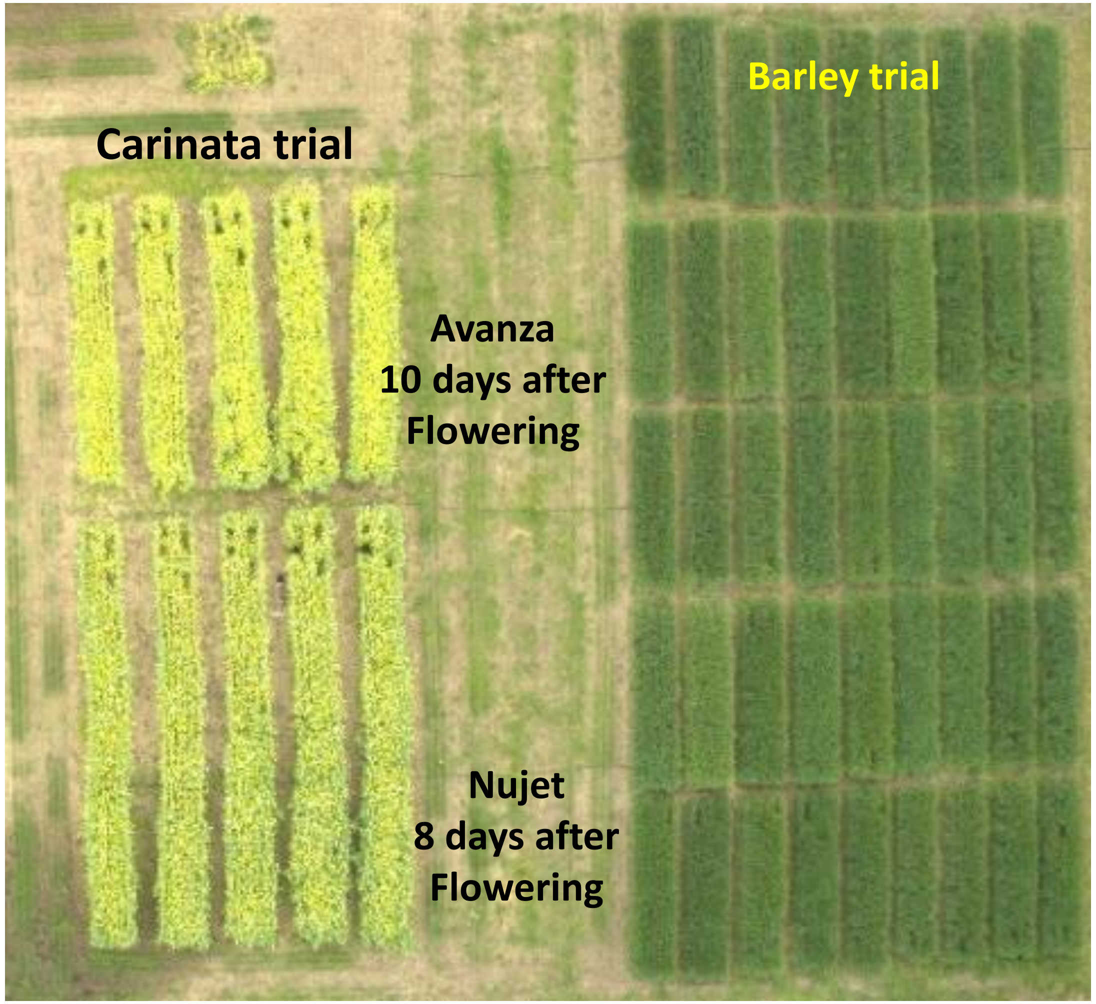






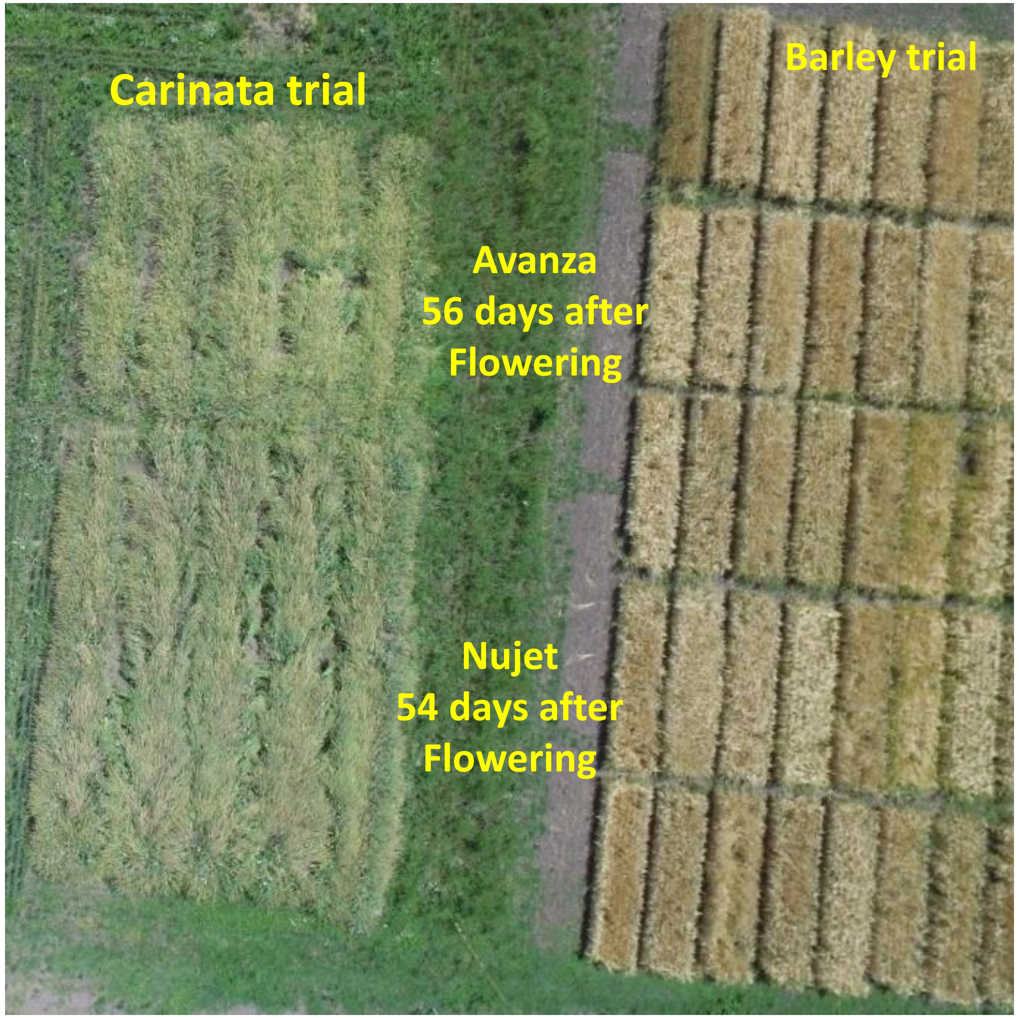
Flowering

September 27
86 DAE

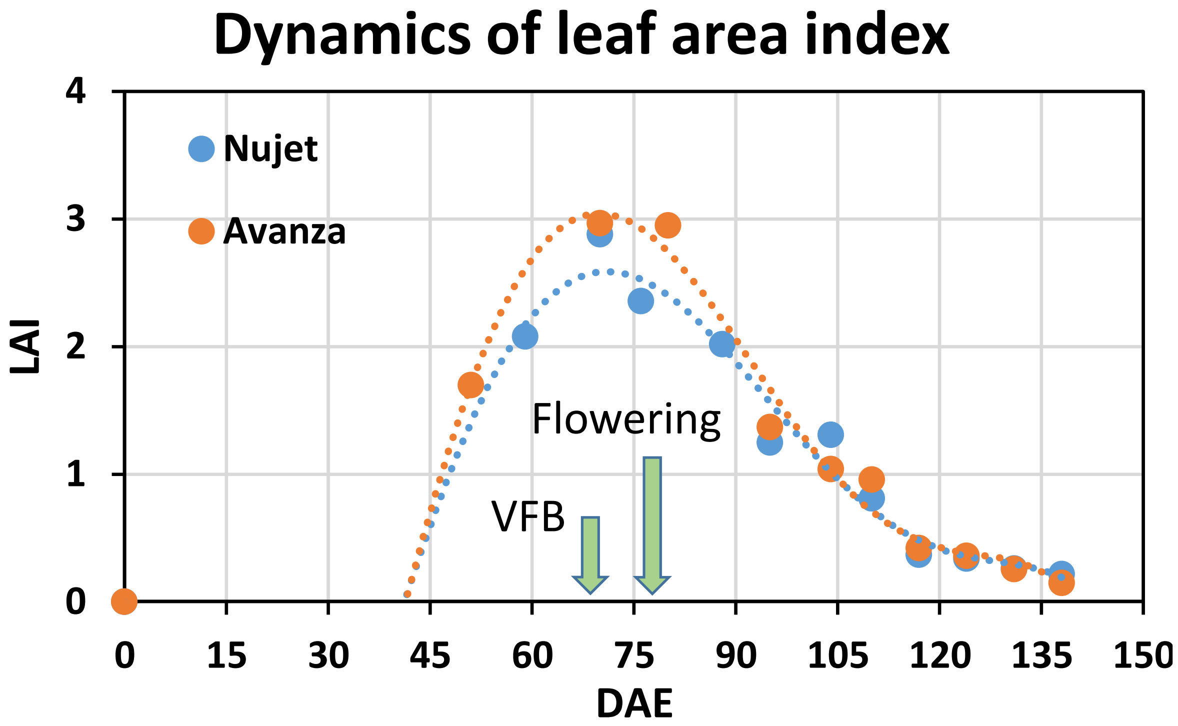


Grain filling (coloured grains)

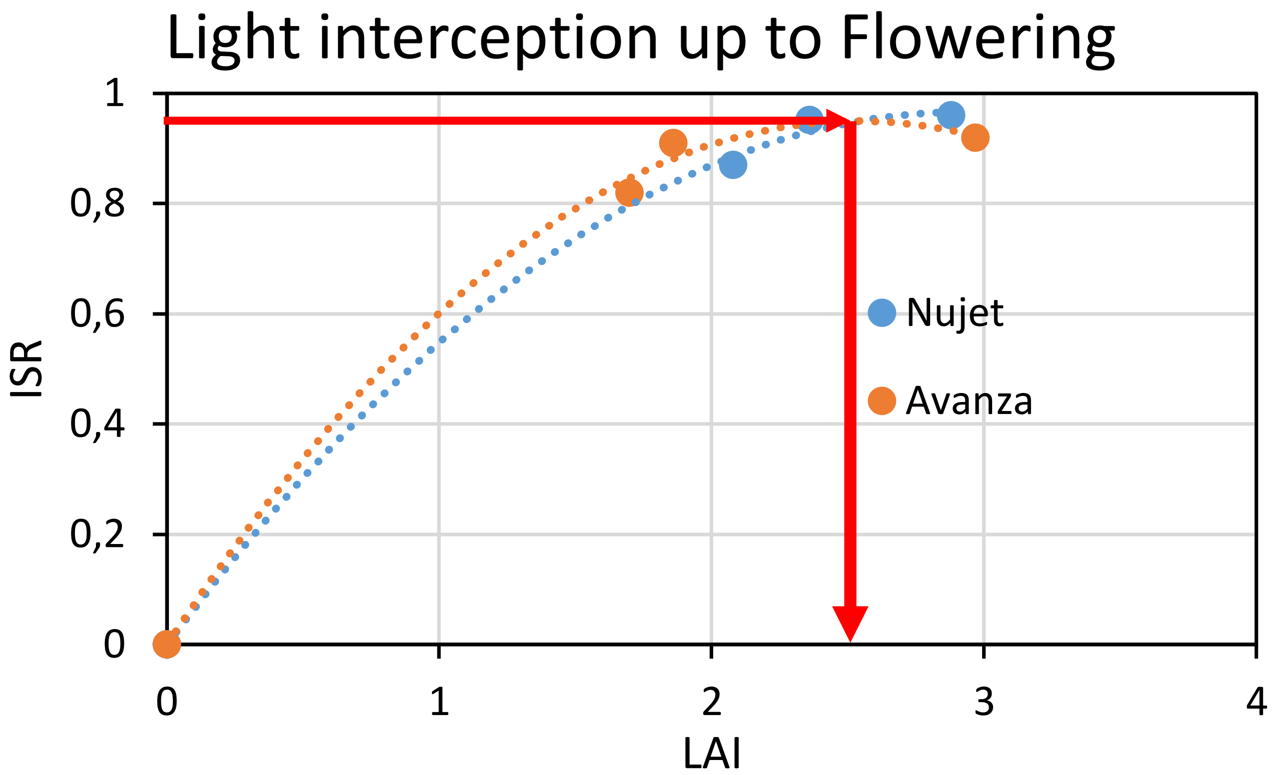
November 12
132 DAE



Leaf area index



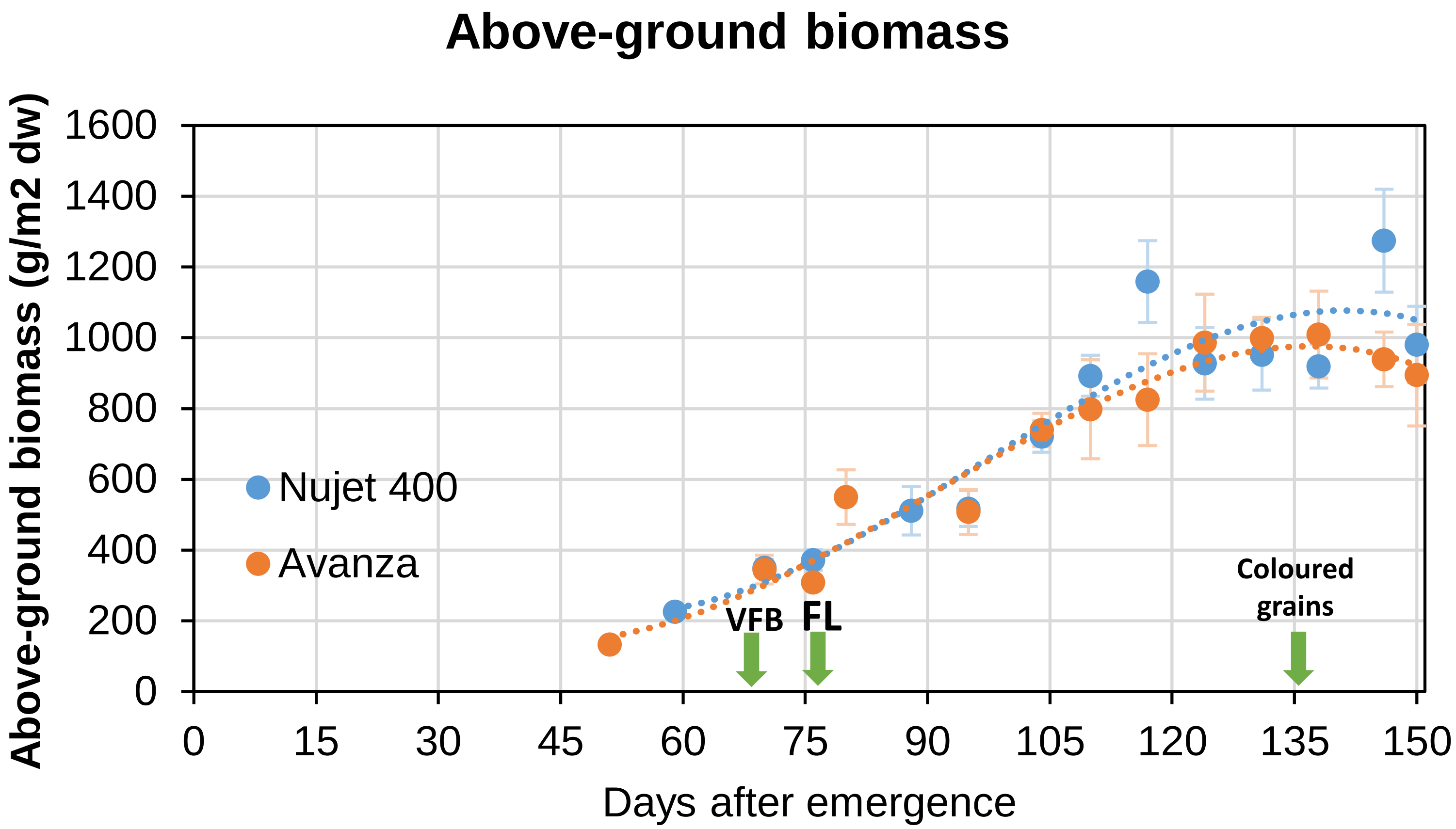
-Maximum LAI (=3) at visible floral bud
-Rapid decrease in LAI from flowering
(shading and replacing by siliques area)



-Maximum intercepted solar radiation (ISR) at LAI=2.5-3
(more early data points are needed)

-Total LAI comes 88% from the main stem leaves and only 12% from branches
-Maximum light capture efficiency (>95% ISR) with LAI = 2.5-3 is typical for Brassicas (and other broadleaf crops)

Aerial biomass growth



Aerial biomass at Flowering:

Aerial Biomass at 76 DAE Begining of Flowering	Kg/ha DW
Nujet 400	3700 ± 280
Avanza	3100 ± 180

Aerial biomass at final Harvest:

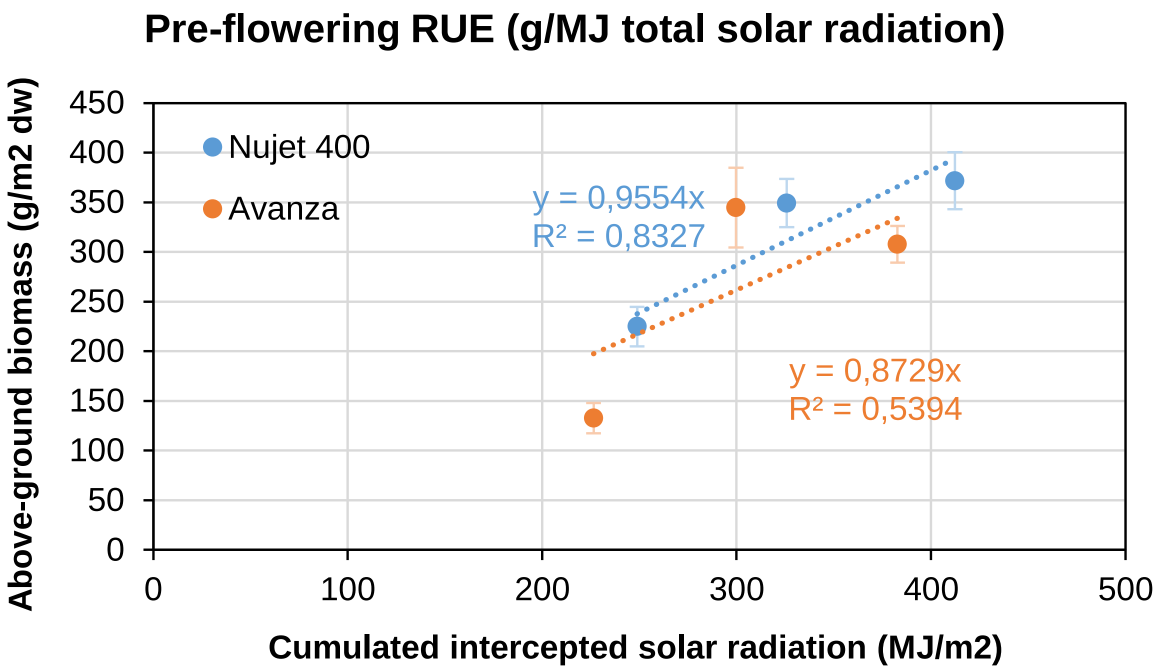
Aerial Biomass at 150 DAE	Kg/ha DW
Nujet 400	9813 ± 1076
Avanza	8943 ± 1437

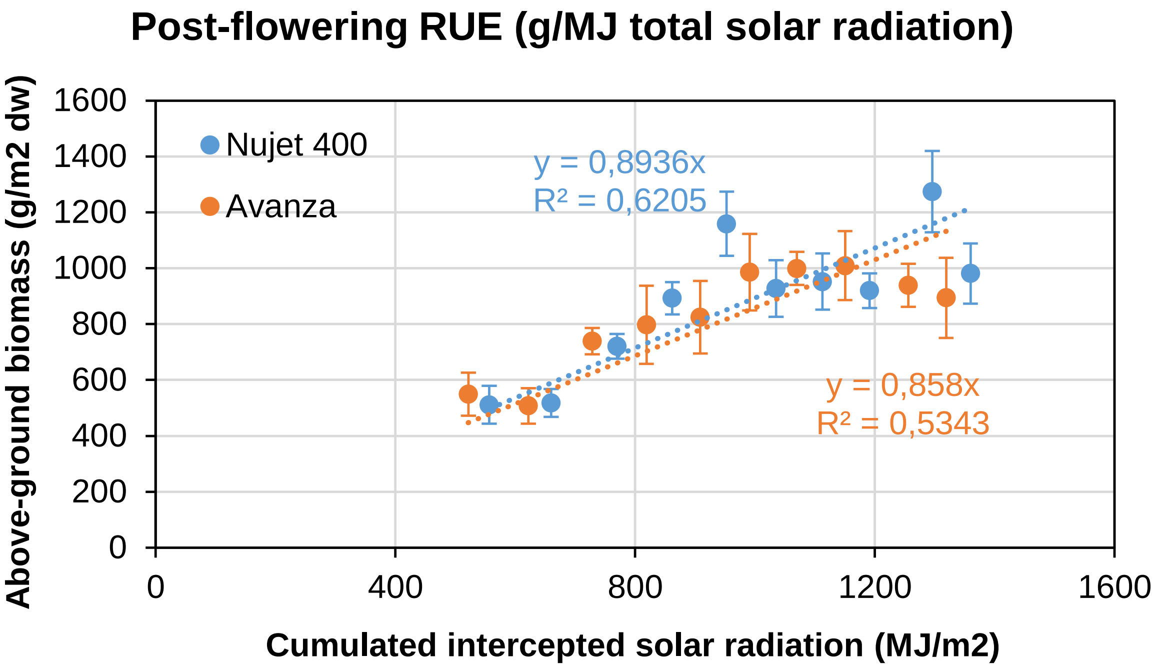
-Typical sigmoid pattern

-Only 1/3 of biomass grows until flowering, the remaining 2/3 grow after flowering

-Both genotypes reach similar biomass at harvest (p=0.64)

Radiation-use efficiency pre and post-flowering



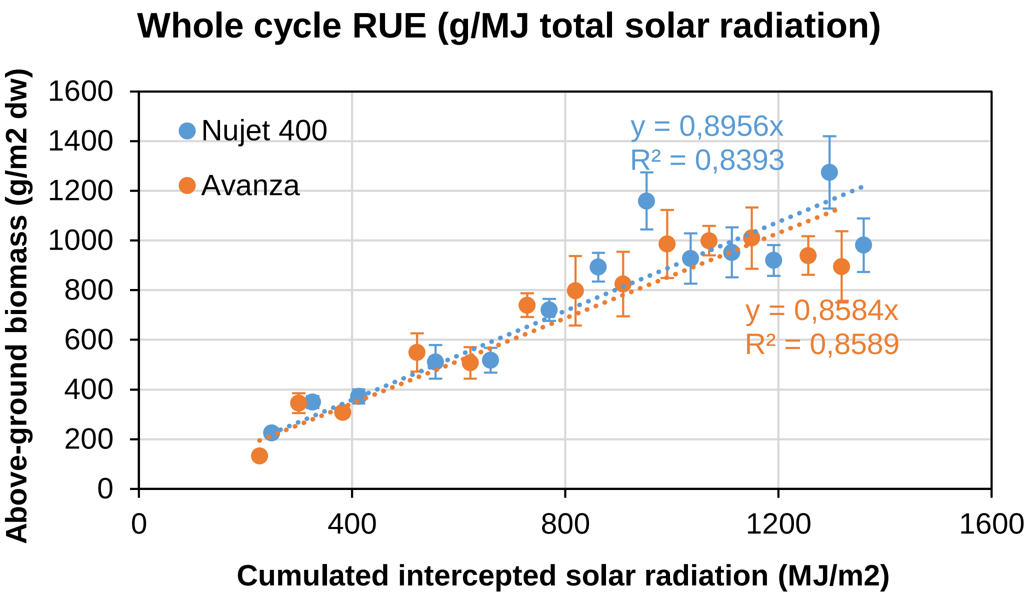


RUE pre-flowering (few data points)
0.87-0.95 g /MJ total intercepted solar radiation
Lower value than canola pre-flowering (typically 1.35 g/MJ) and other C3 crops (1.2-1.7 g MJ)

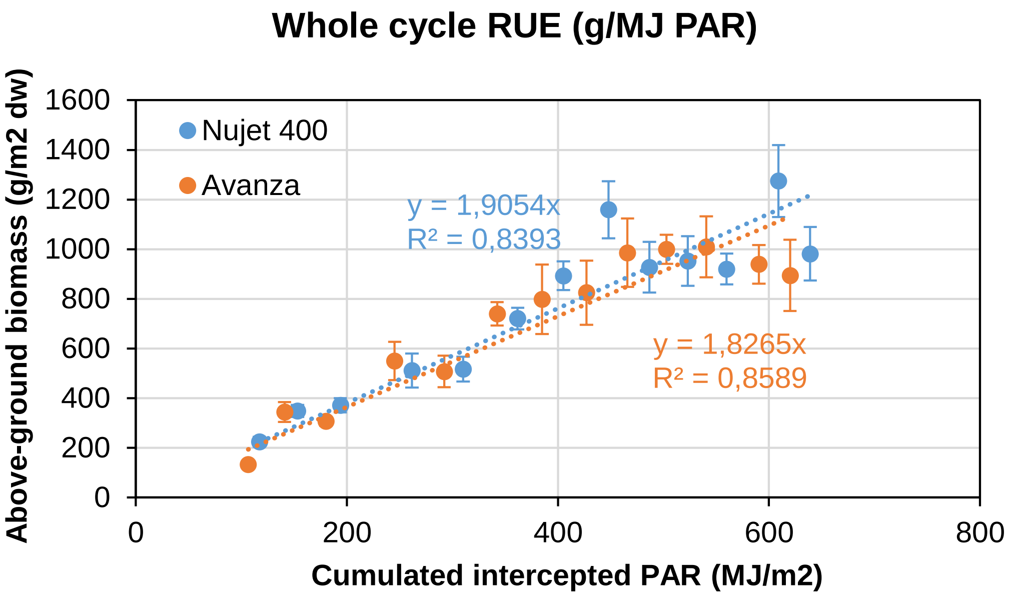
RUE post-flowering
0.85-0.89 g /MJ total intercepted solar radiation
A **higher value** than canola post- flowering (typically 0.4-0.75 g/MJ) possibly associated to more open and lax inflorescences improving sunlight canopy distribution
Similar RUE in both genotypes

Radiation-use efficiency <u>for the whole cycle</u>

Total intercepted solar radiation



Intercepted Photosynthetically Active Radiation



RUE: **0.85-0.90** g biomass per MJ intercepted total solar radiation (lower than canola, around 1 g/MJ Kuai et al 2015)

RUE: **1.8-1.9** g biomass per MJ PAR intercepted

For the whole cycle, corrected biomass by energetic cost is better
especially during stem growth (is rich in lignin) and during grain-filling period (oil and protein)

Radiation-use efficiency for corrected biomass

<u>Assumptions</u>: 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).

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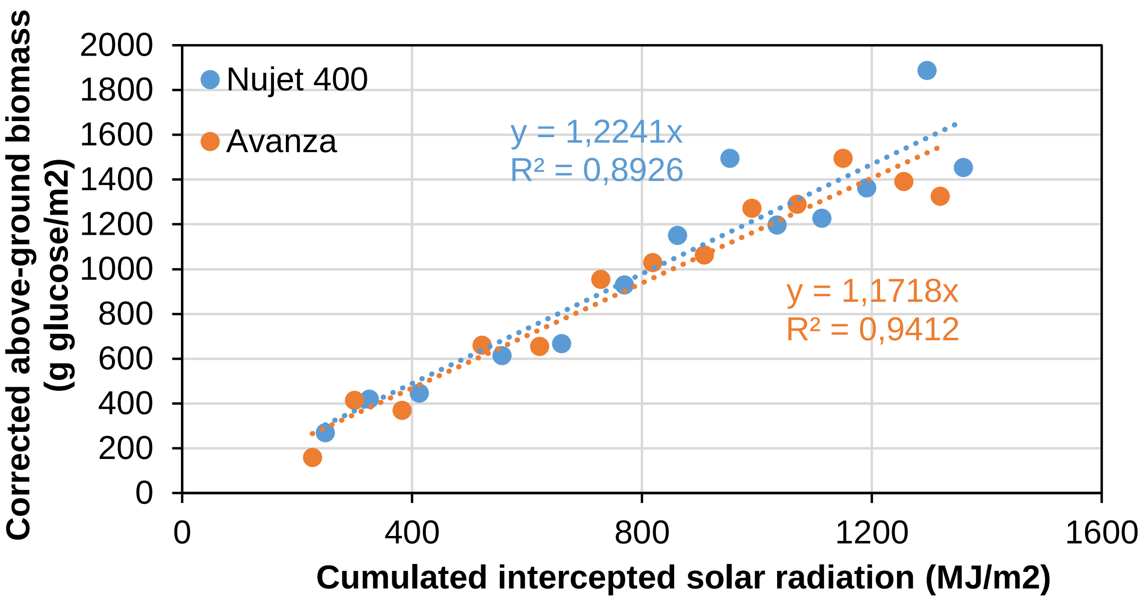
Table 1. Glucose required for synthesis of 1.000 g of a component, and concurrent respiration, expressed in CO_2 and in O_2.

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	-.045	0.270

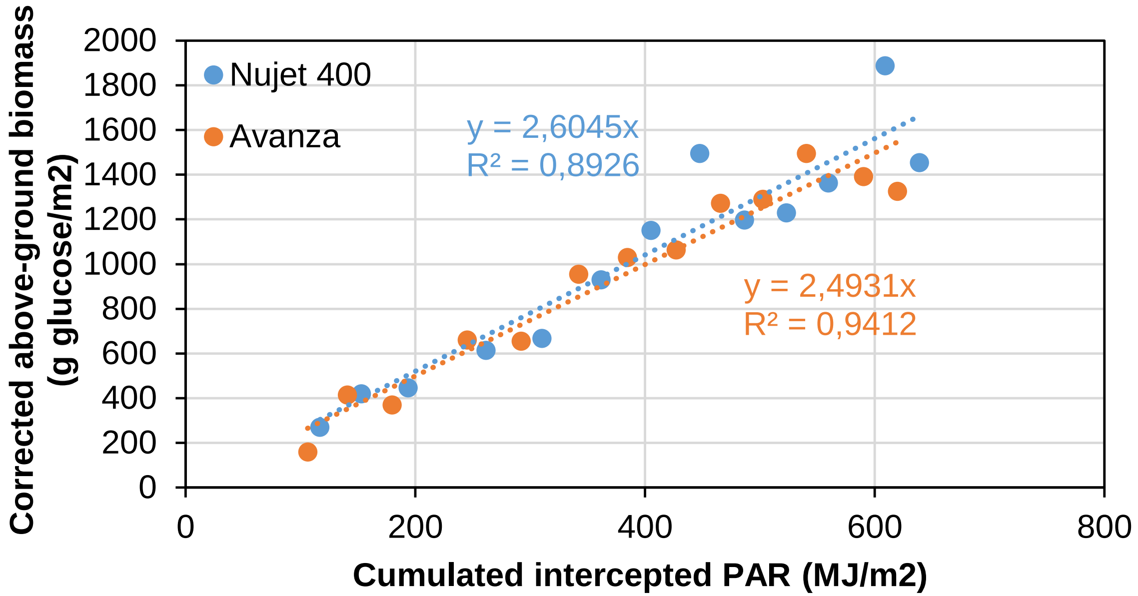
As expected, pre and post-flowering RUE <u>are similar and linear</u> when energetic cost of biomass in taken into account

Whole cycle RUE (g glucose /MJ)



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

Whole cycle RUE (g glucose /MJ PAR)

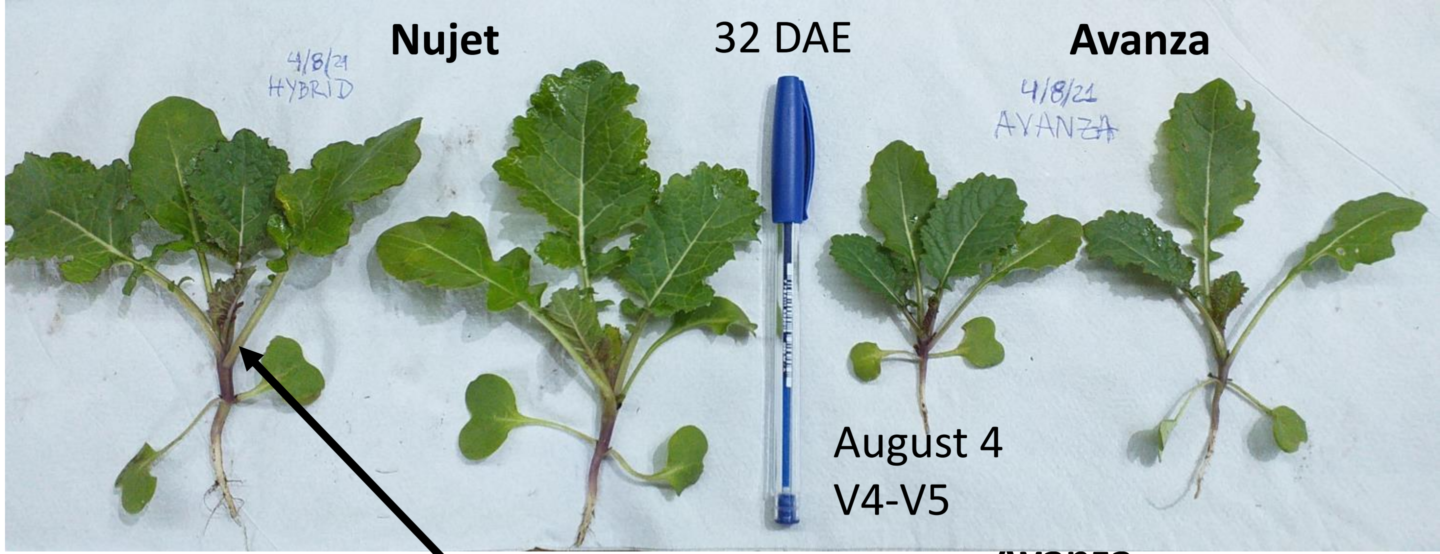


RUE = **2.5** g glucose/MJ PAR

In the lower range of 2.6-5.6 for canola from Dreccer et al. (2000)

Aerial biomass

Nujet 32 DAE **Avanza**



August 4
V4-V5

Nujet 400
August 21 (V7-V8) Few branches Petiole base violet

Avanza
August 21(V7-V8) Already has branches!

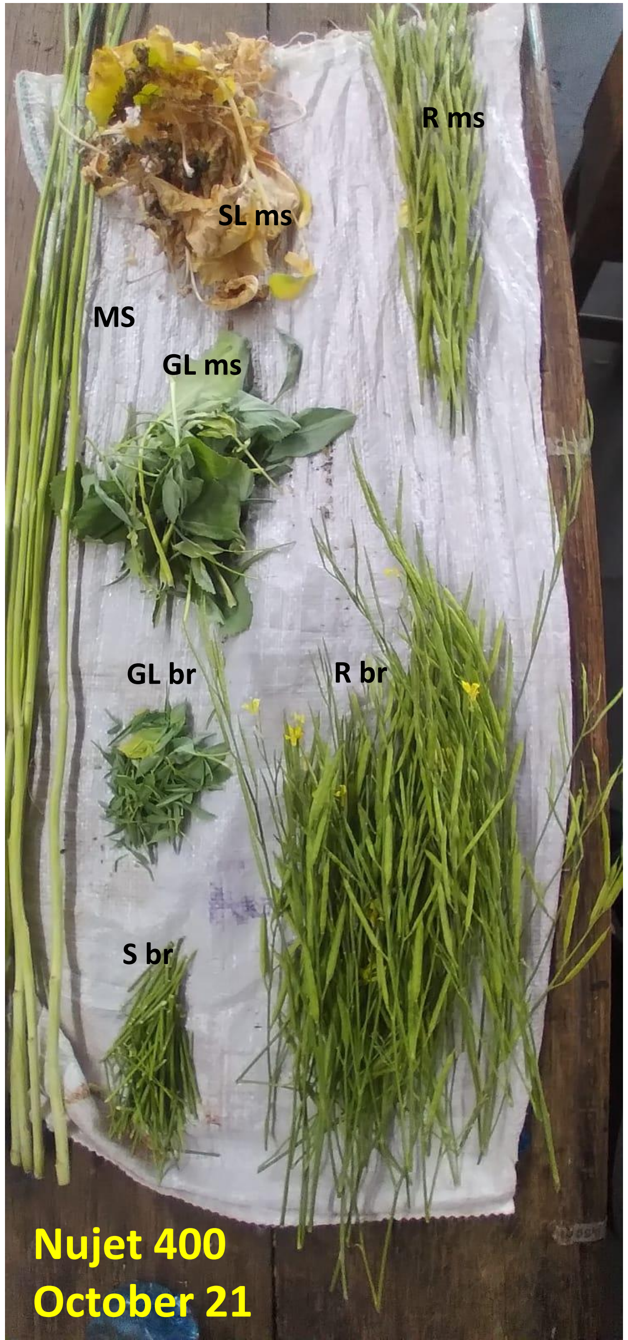
49 DAE

Biomass allocation

86 DAE

105 DAE

120 DAE



Biomass allocation

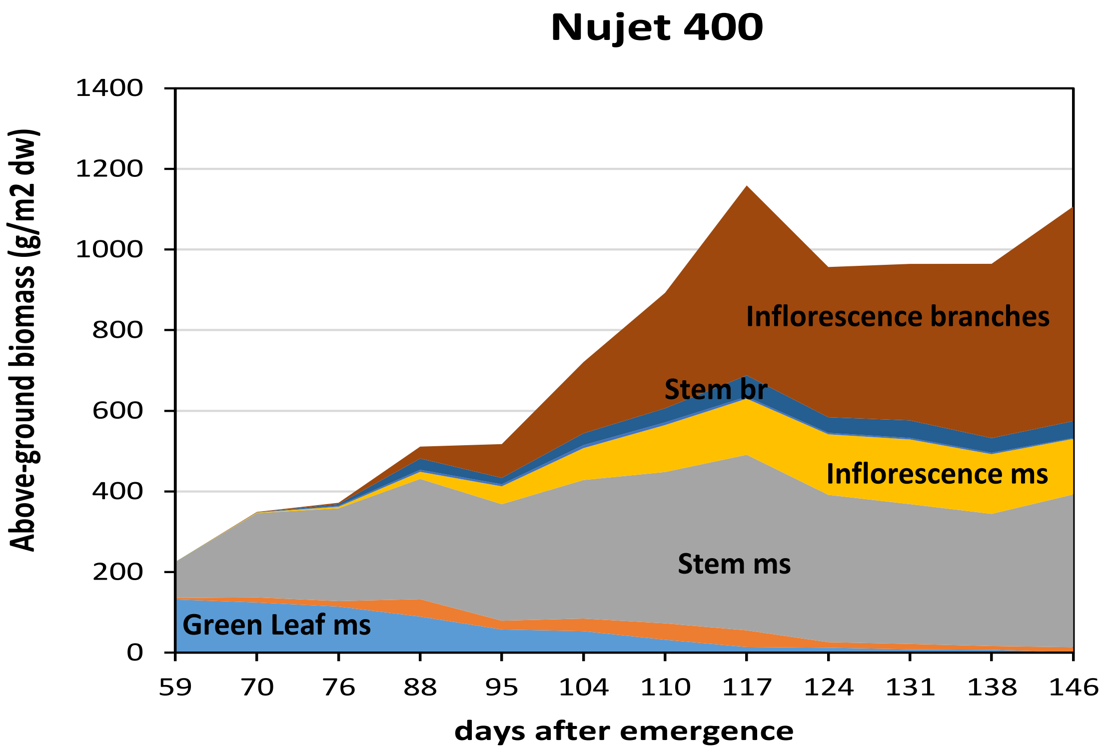
November 11 (131 DAE)

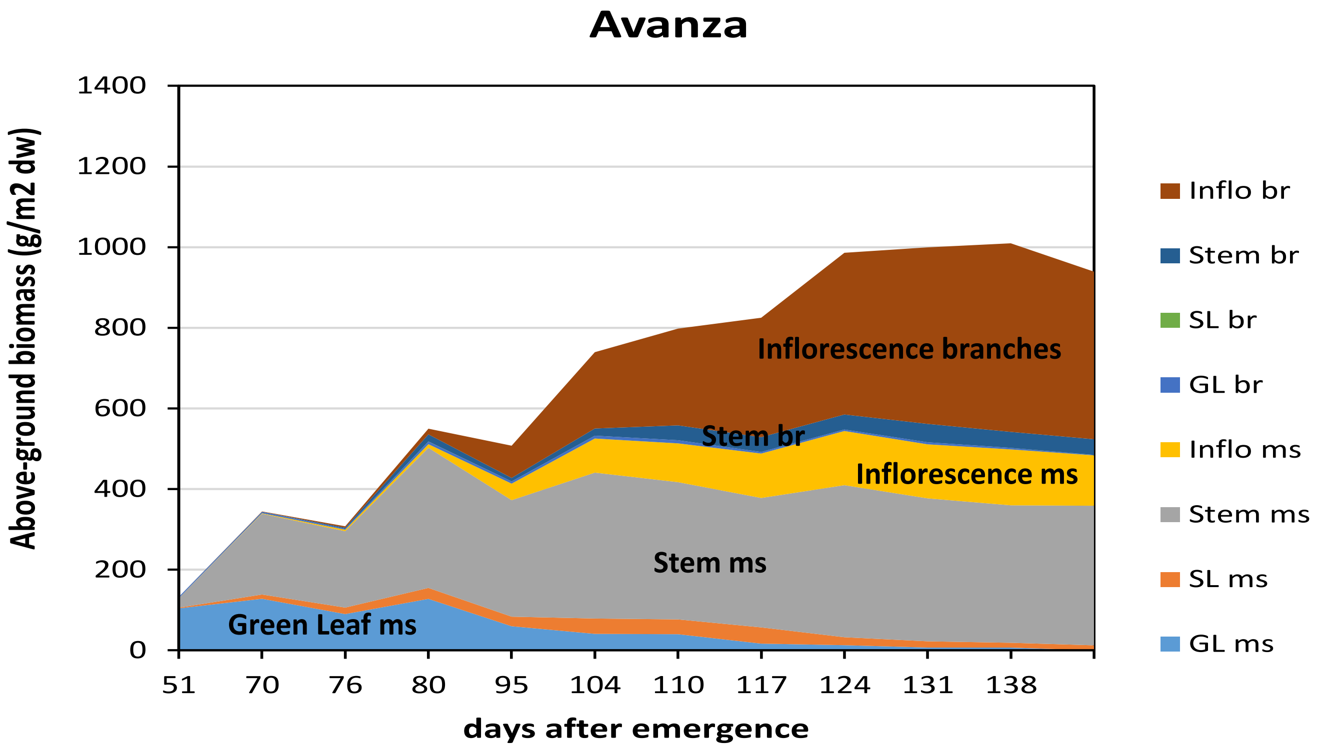
Fast drying (2 weeks)

November 26 (146 DAE)

Biomass allocation

ms: from main stem
br: from branches





-Similar biomass allocation in both genotypes

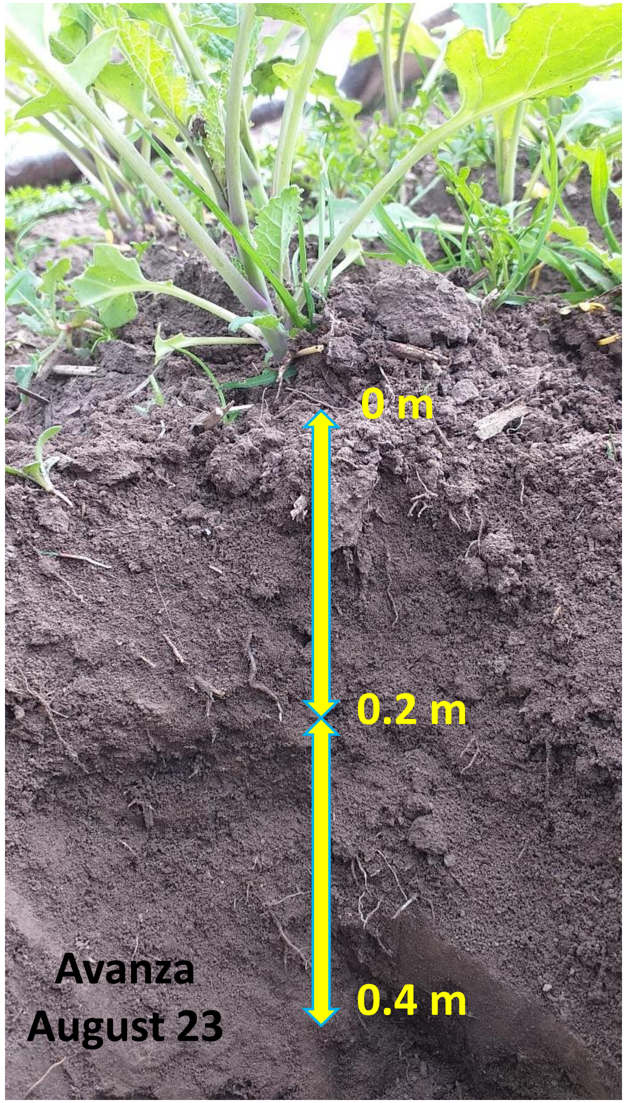
-Most of biomass is in branches (45%)

-Main stem retains 35% of the biomass at harvest

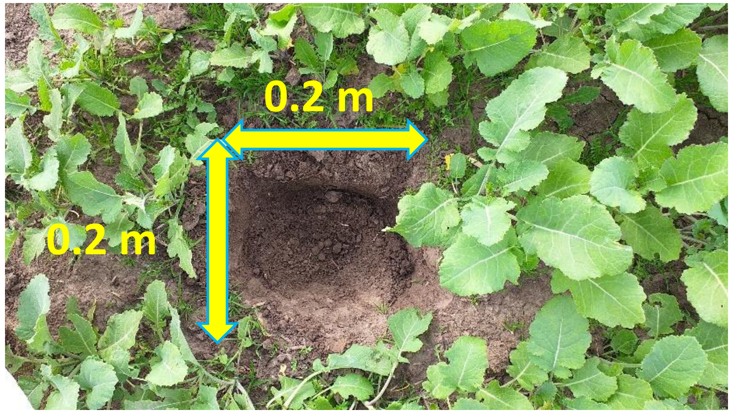
131-146 DAE	Nujet	Avanza
Stem ms	35 %	35 %
Inflorescence ms	15 %	13 %
Inflorescence br	**45 %**	**45 %**

Root sampling

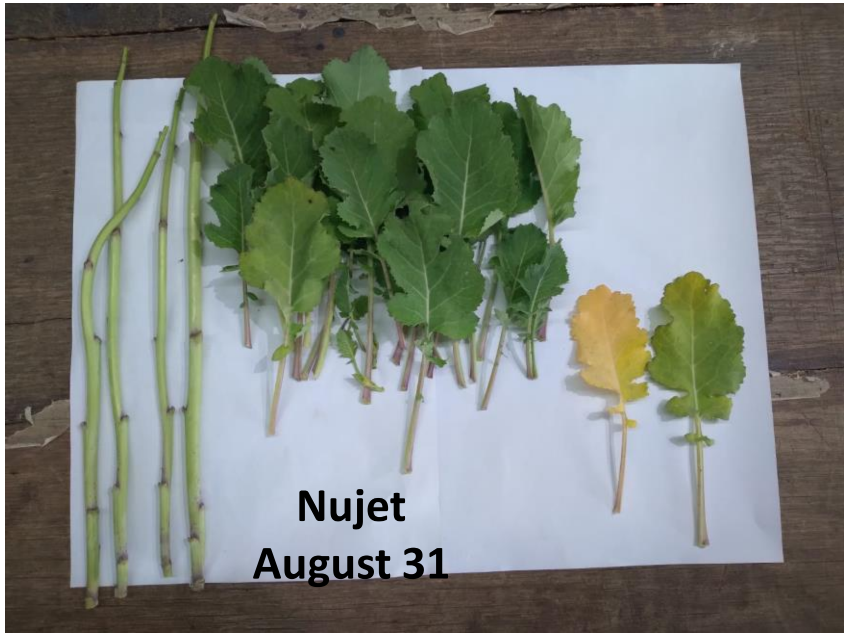
Area = 0.2 x 0.2 m (row centered) x 0.4 m total deep



No roots below 0.4 m

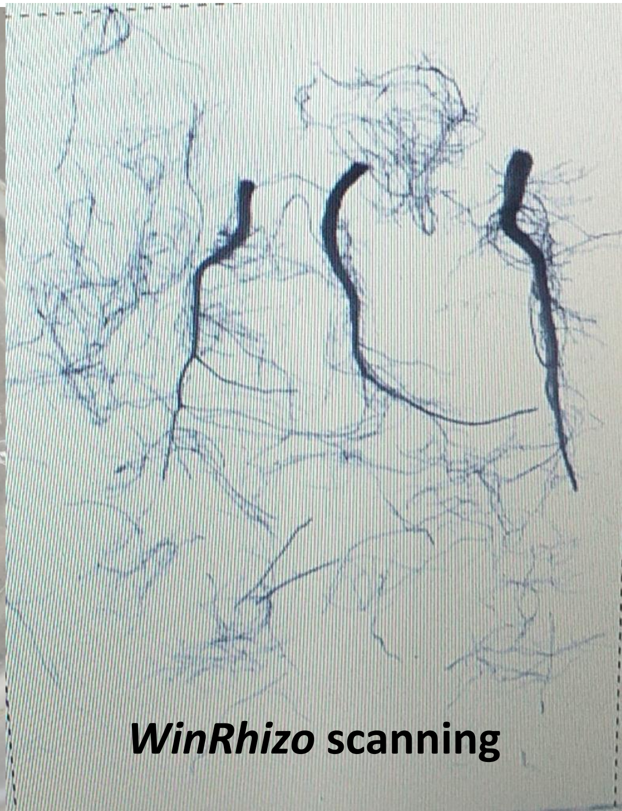


Root sampling



Root washing, scanning and drying

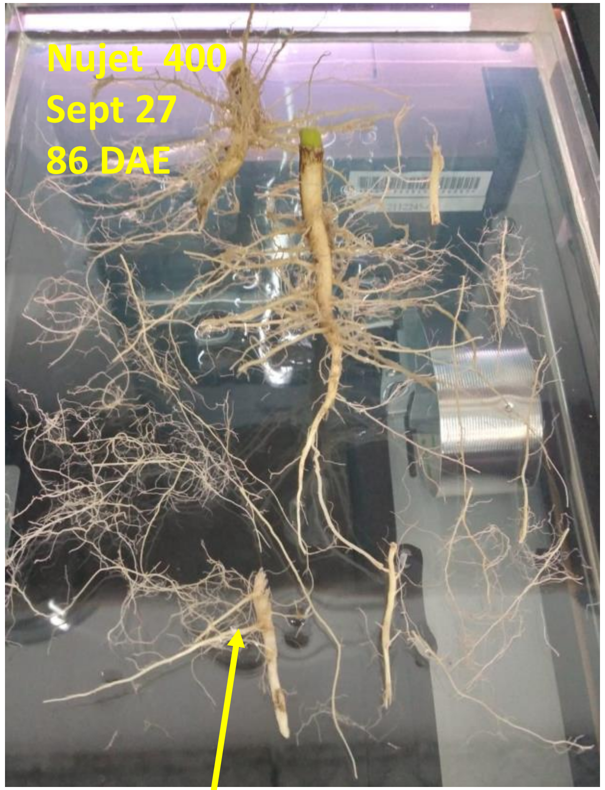
Time consuming!
0-0.2 m ≈ 10 kg soil (whole sample)
0.2-0.4 ≈ 2.5 kg soil (aliquot 25%)
12.5 kg soil washed per plot= **125 kg soil per sampling date (two weeks with 3 full technician)**

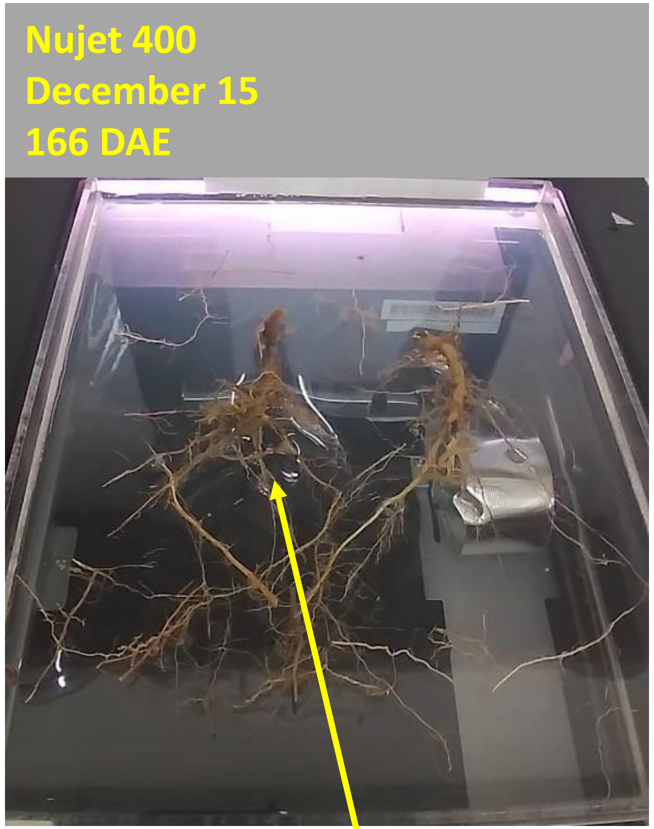


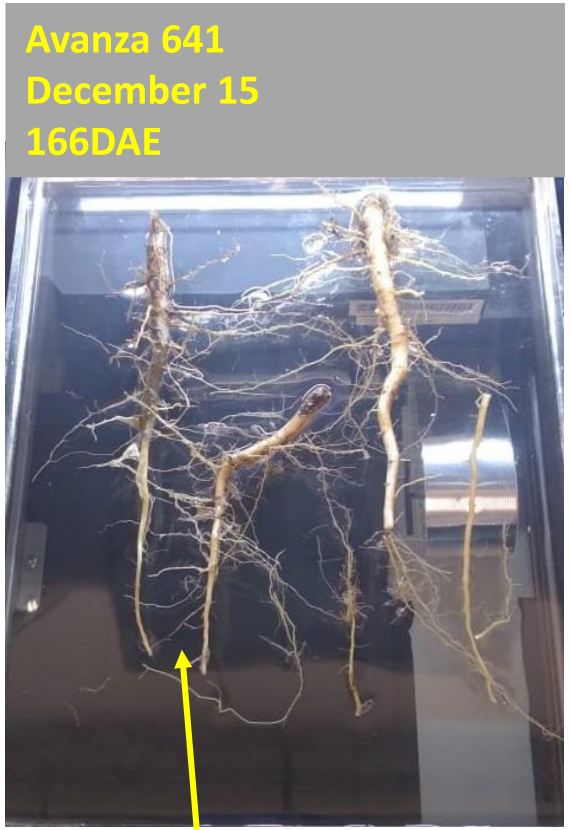
Root lenght

Around the beginning of Flowering

After maturity







Shallow lateral roots at 90º

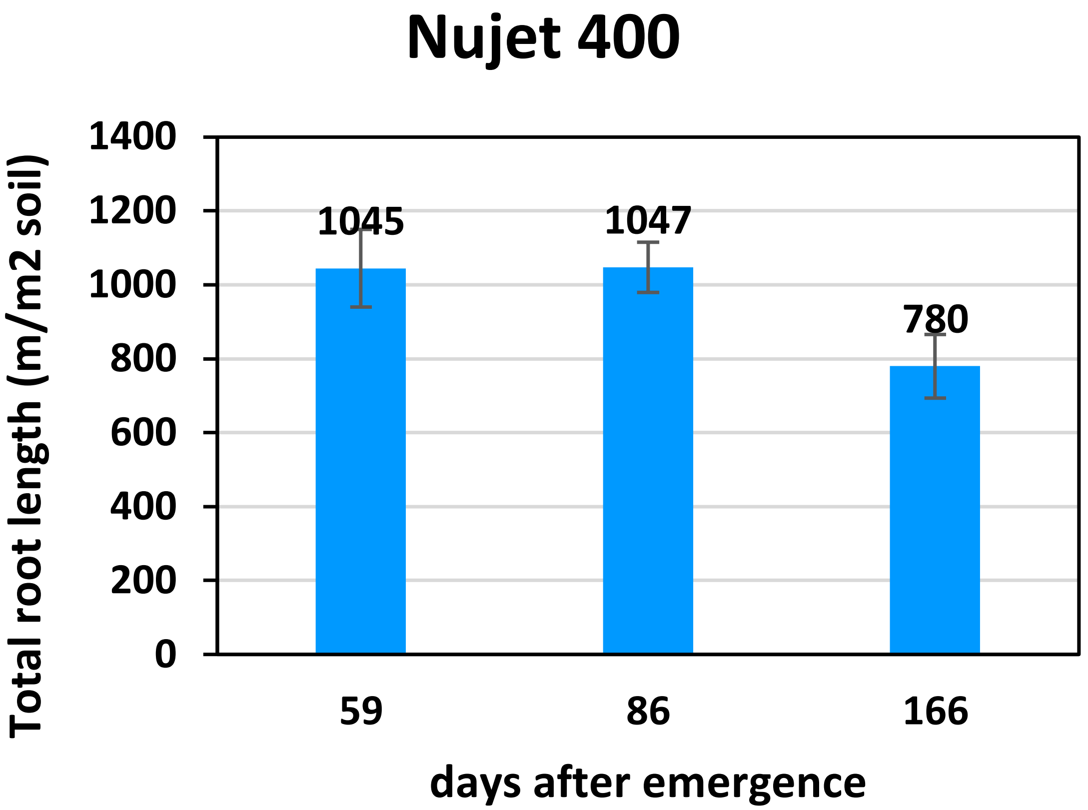
Fine, bright root hairs

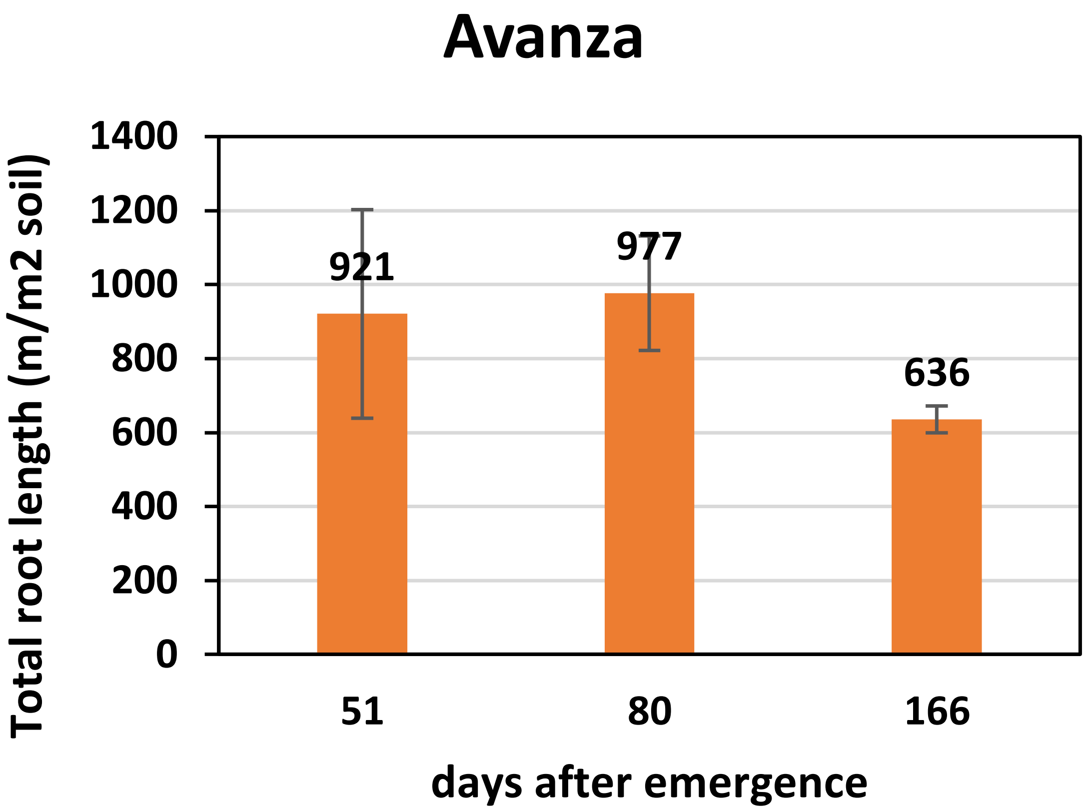
Heavy, long taproot

Dark brown colour

Few root hairs

Root lenght

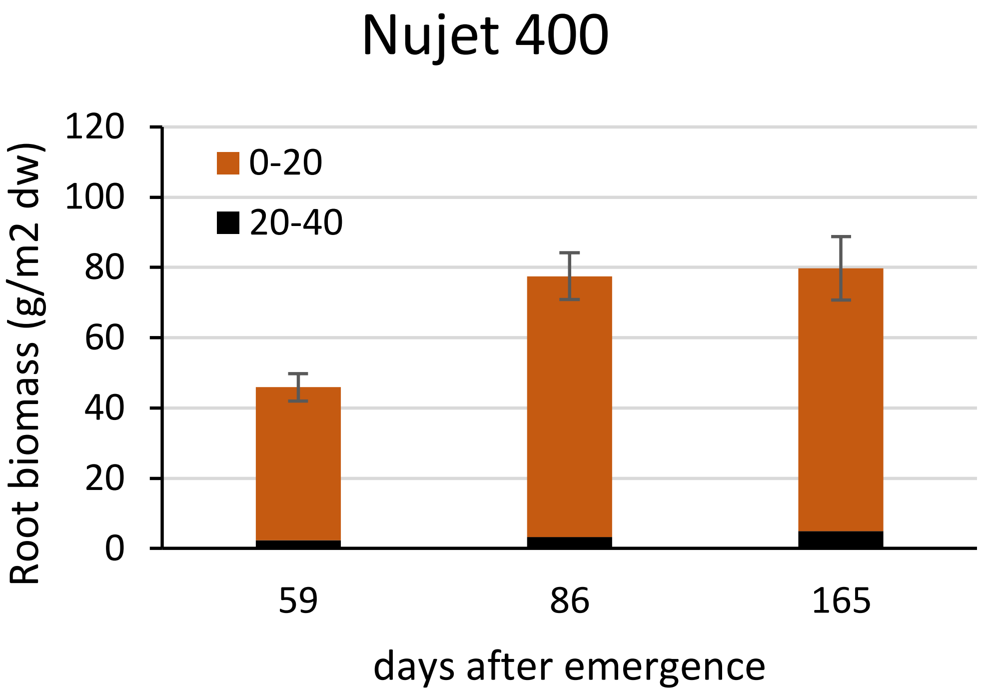


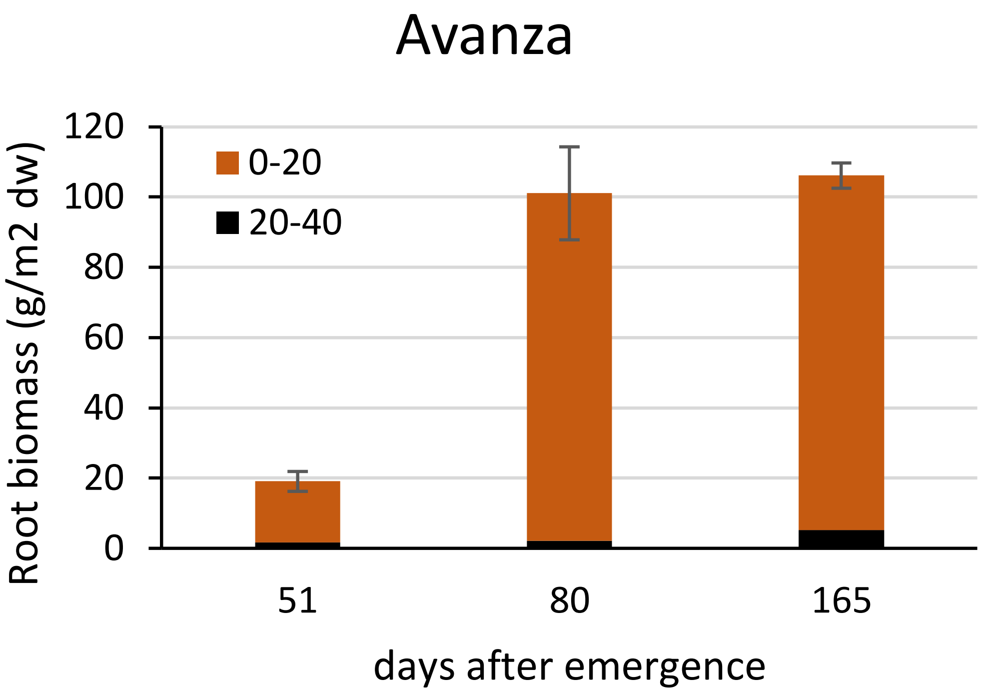


At flowering ≈ 1 kilometer roots per m² soil
(lower than 2-3 km/m² reported in canola)
Zhang et al (2005) AJAR

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

Root biomass





-Roots were <u>mainly in the topsoil</u> and did not deepen beyond 0.4 m (strong Bt clay horizon)

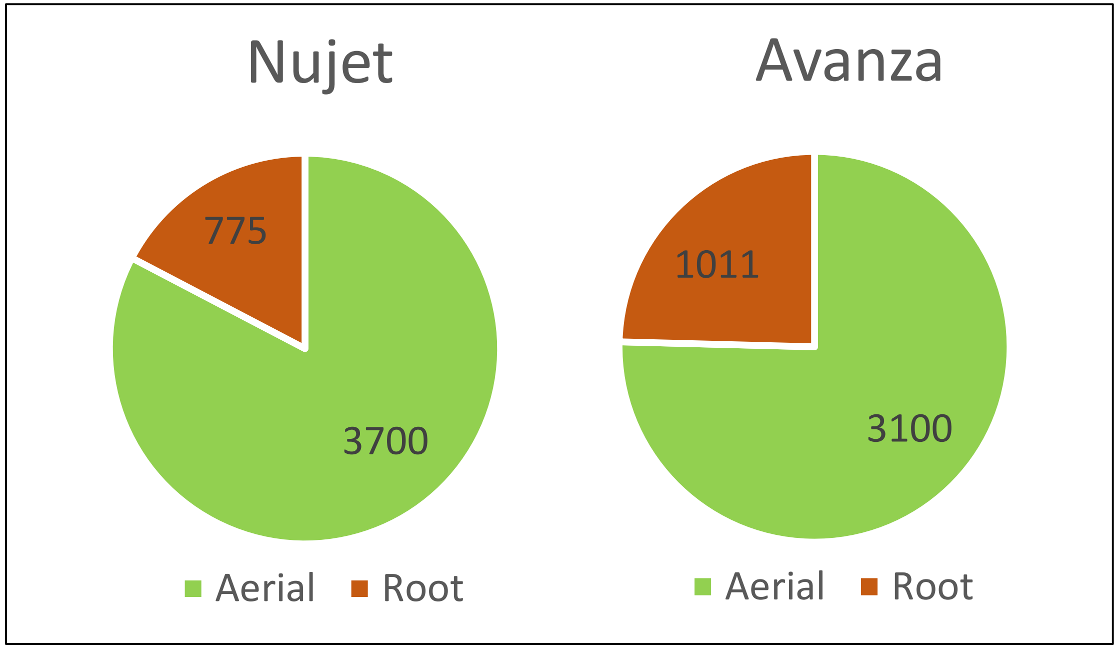
-<u>At flowering</u> ≈ 800-1000 kg/ha of dry biomass allocated in roots (20-30% of aerial biomass)

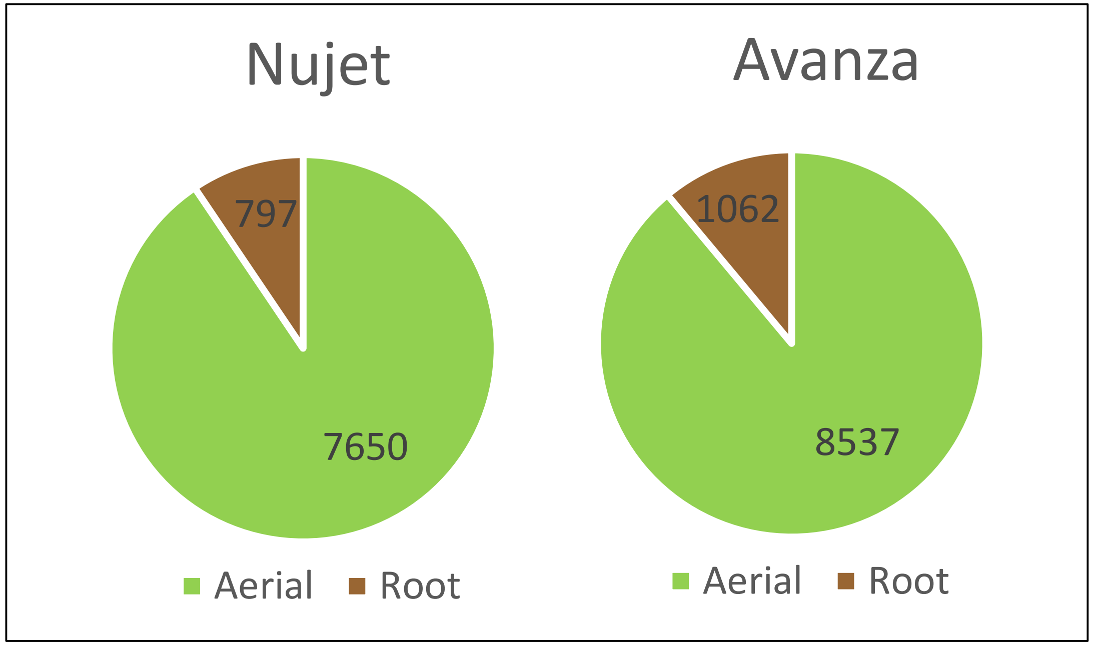
-Root biomass <u>did not increase post-flowering</u> (but aerial biomass increase twice)

Total root weight <u>similar to B. carinata in Uruguay</u> (85-140 g/m2) Mazzilli & Ernst (2021)
and mustard (50-80 g/m^2) Gan et al (2009) CJPS and within range for canola (100-160 g/m^2) Zhang et al (2005) AJAR, Gan et al (2009) CJPS, Wu et al (2020) FPS

Root/aerial 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	Avanza
Aerial (Kg/ha DW)	**3700 ± 280**	**3100 ± 180**
Root (Kg/ha DW)	**775 ± 60**	**1011± 135**
Root/aerial ratio	**0.21**	**0.33**

Total Biomass (15 days after Maturity)	Nujet	Avanza
Aerial (Kg/ha DW)	**7650 ± 1154**	**8537 ± 1190**
Root (Kg/ha DW)	**797 ± 97**	**1062 ± 37**
Root/aerial ratio	**0.10**	**0.12**

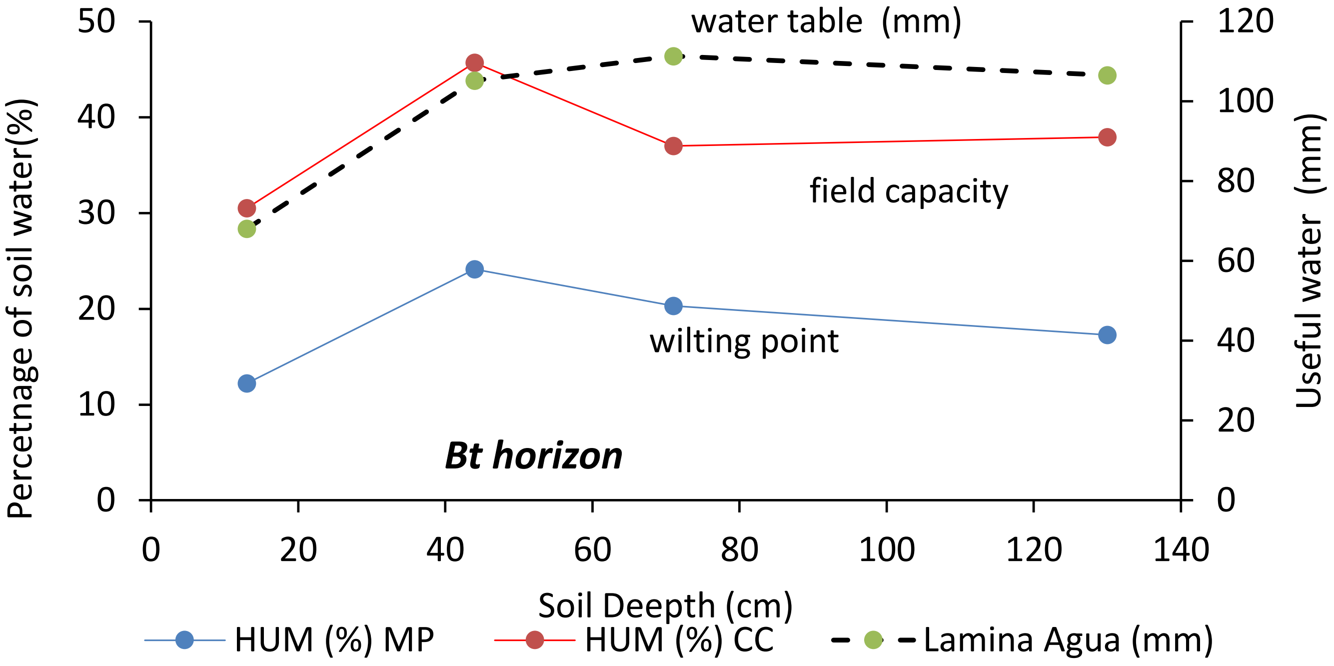
Shoot/root ratio at harvest (8-10) is in the range of B. carinata in Uruguay (7.5-11) Mazzilli & Ernst (2021)

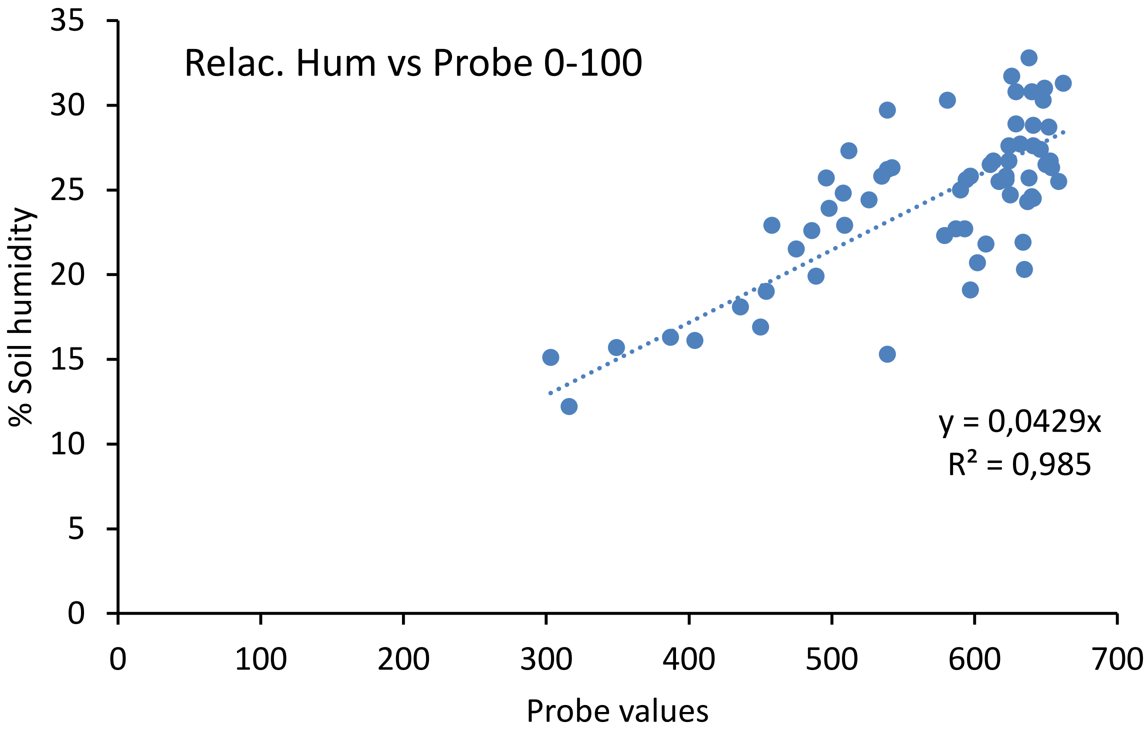
Soil water content:

water table and probe calibration

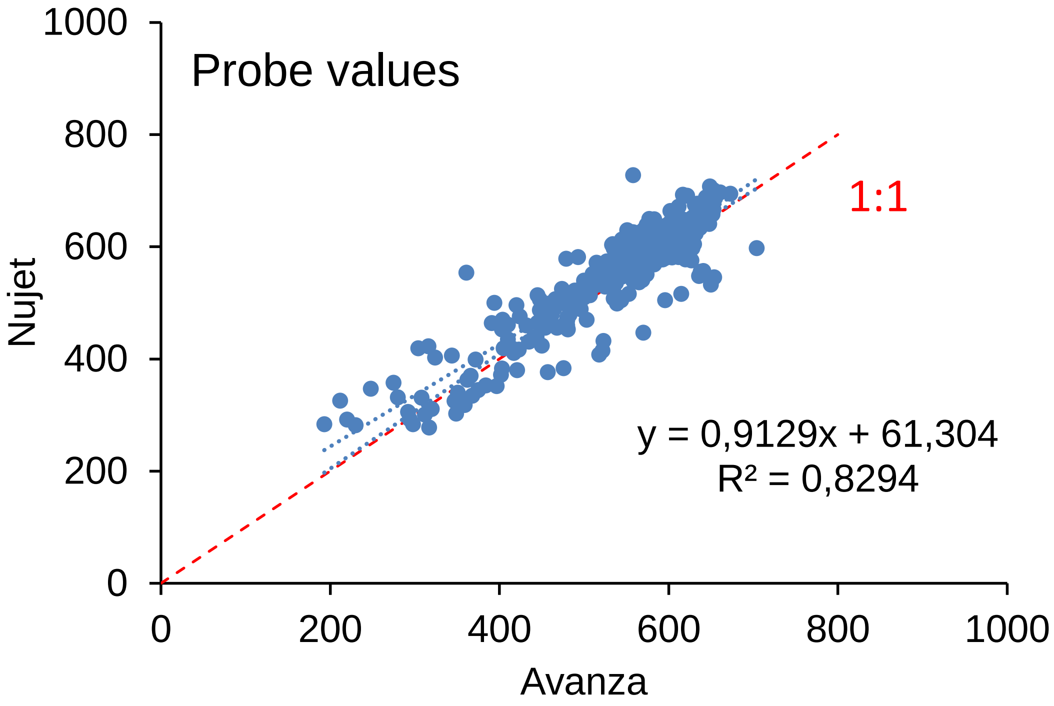
Upper and lower limits of soil was measured and useful capacity at different depths were calculated

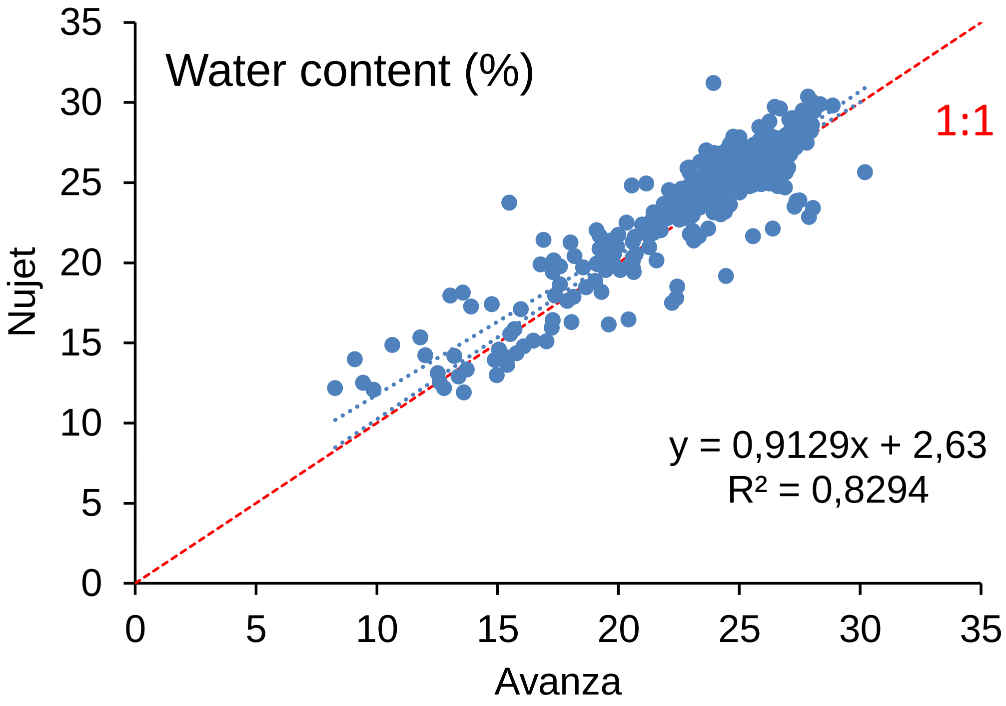
Troxler 4300 depth moisture gauge (Troxler Corp, NC) calibration with gravimetric measurements (0-100 cm depth)





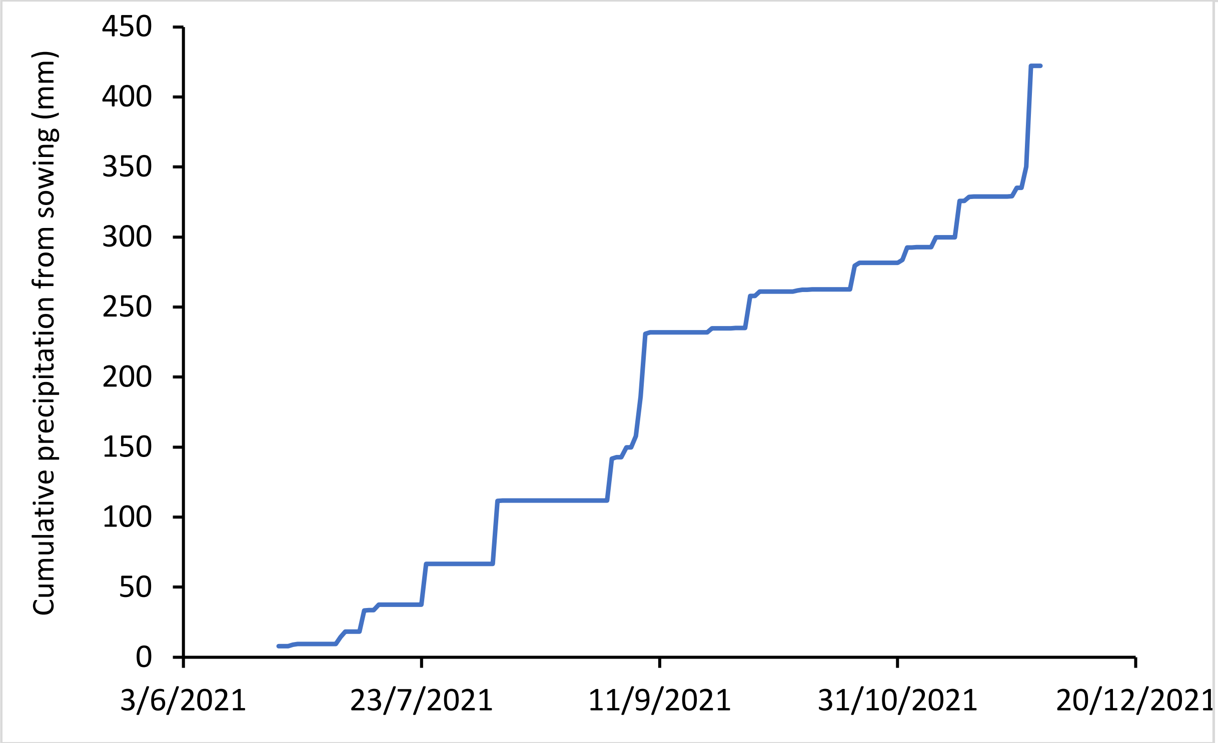
Soil water content: Probes and Water values throughout the crop cycle

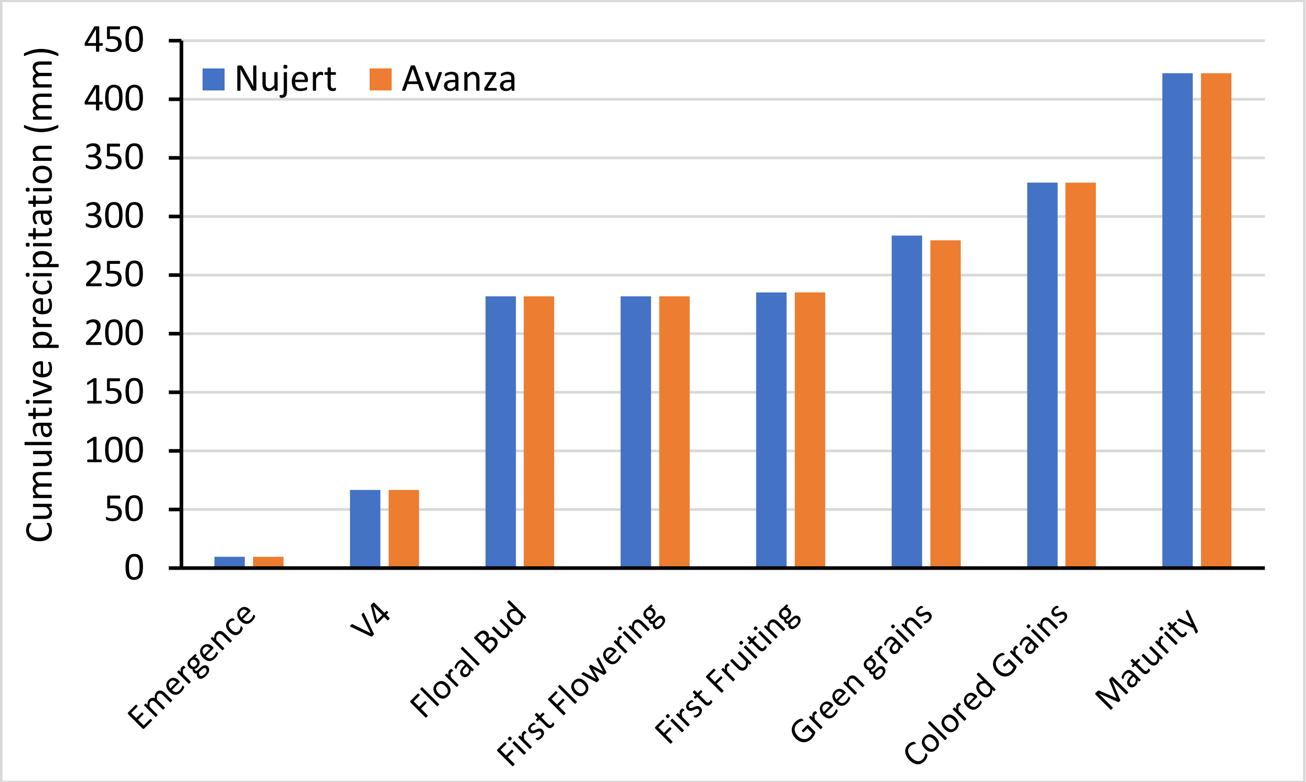




-Similar pattern of soil moisture in Avanza and Nujet

Cumulative precipitation for different crop stages





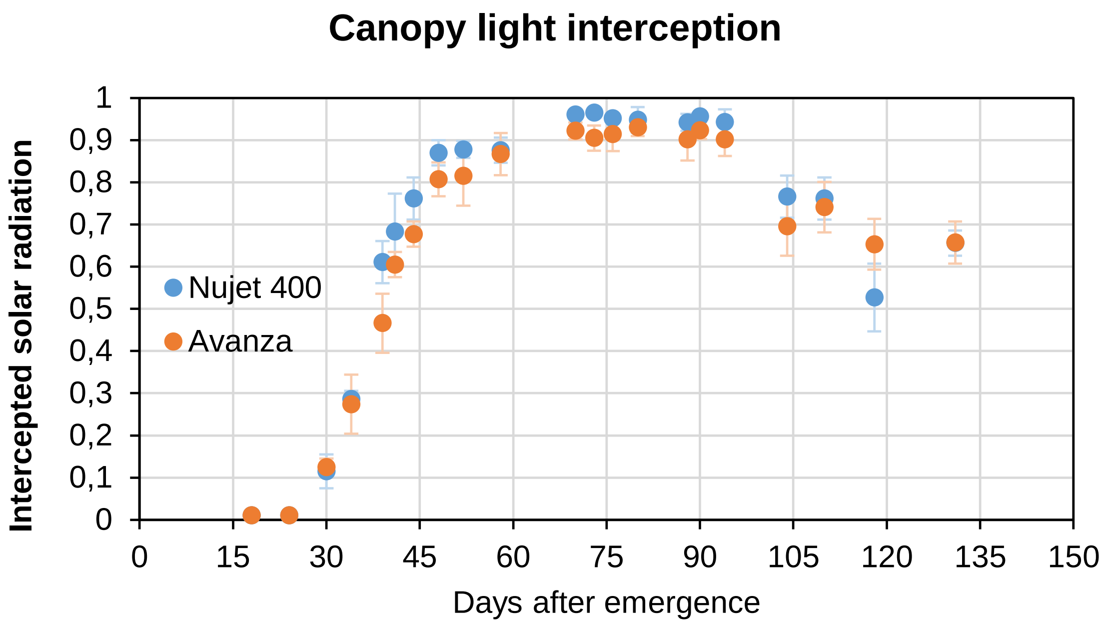
-Cumulative precipitation from sowing to maturity was 422 mm

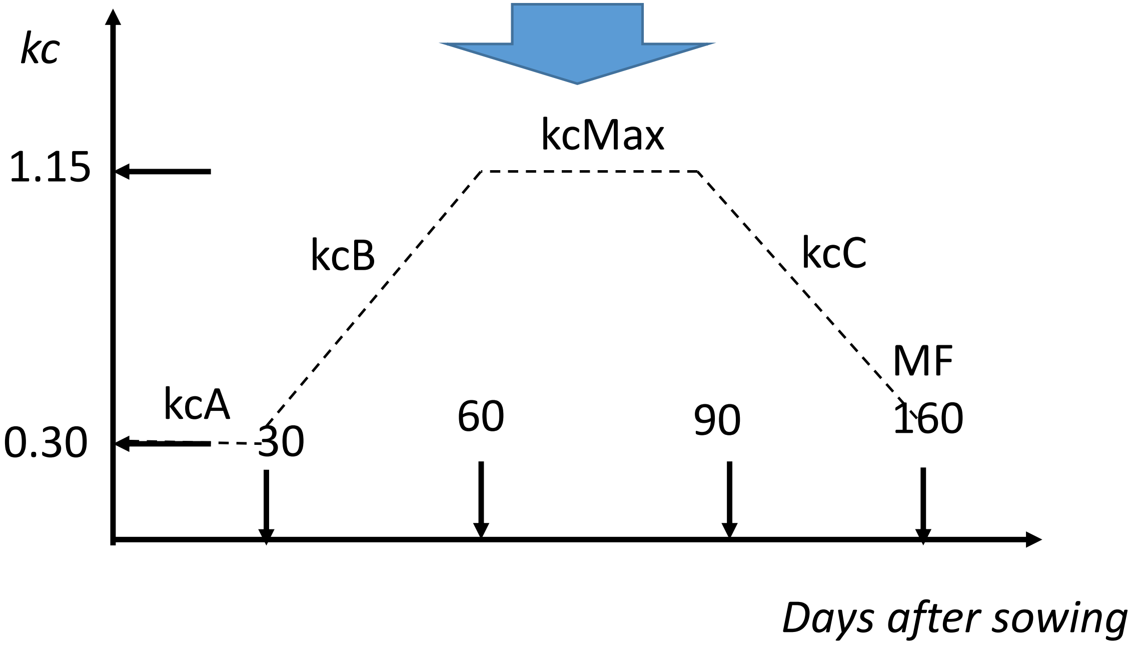
-As crop phenology was similar between Nujet and Avanza, no differences were evident in the cumulative precipitation

-At First flowering cumulated precipitation represented 55% of total (i.e. 232 mm)

-Supplementary irrigation was applied (but not measured properly)

Crop Evapotranspiration (ETc) estimation: Kc





-Kc coefficient calculated taking account the dynamic of canopy light interception

-Maximum Kc was 1.15 (between 60 and 90 days after sowing)

-Minimum Kc was 0.30 (Andriani 2017 & FAO).

Equations:

KcA=0.3 (from sowing to 30 DAS)

KcB: Y= 0.975+0.0425x (from 30 to 60 DAS)

Kc Max 1.15 (60-90 DAS)

KcC: y= 2.425-0.0142x (from 90 to 160 DAS)

Crop Evapotranspiration (ETc) estimation

Potential Evapotranspiration (Eto): from meteorological data according to the Penman FAO

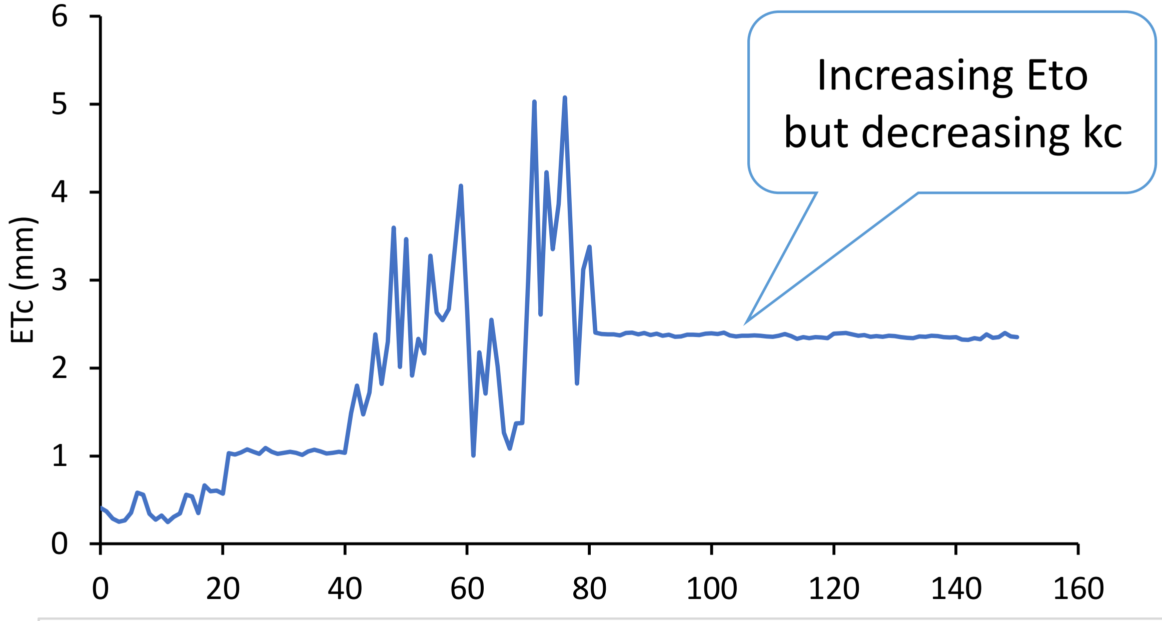
$$ET_o = \frac{0.408\,\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)}$$

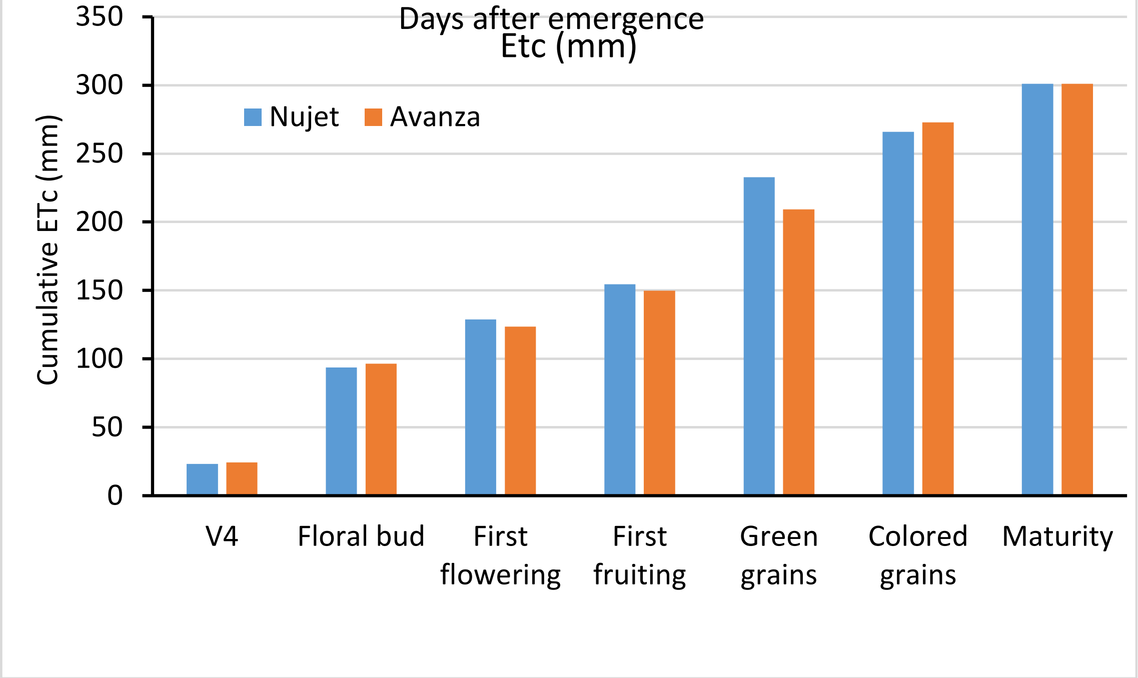
ET_o	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour pressure [kPa],
e_s-e_a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa °C^{-1}],
γ	psychrometric constant [kPa °C^{-1}].

-ETc= Eto x Kc

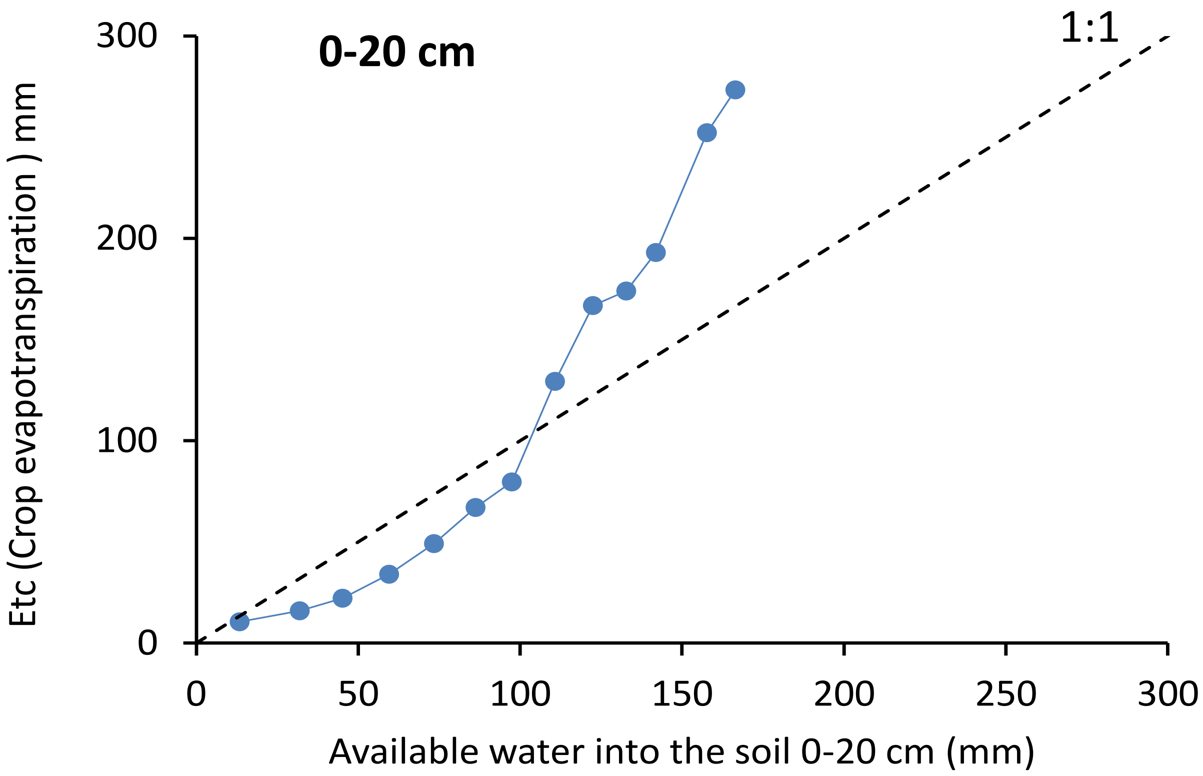
-Crop demand calculated by the evapotranspiration of the crop (ETc) was from 0.5 mm/day to 5 mm/day

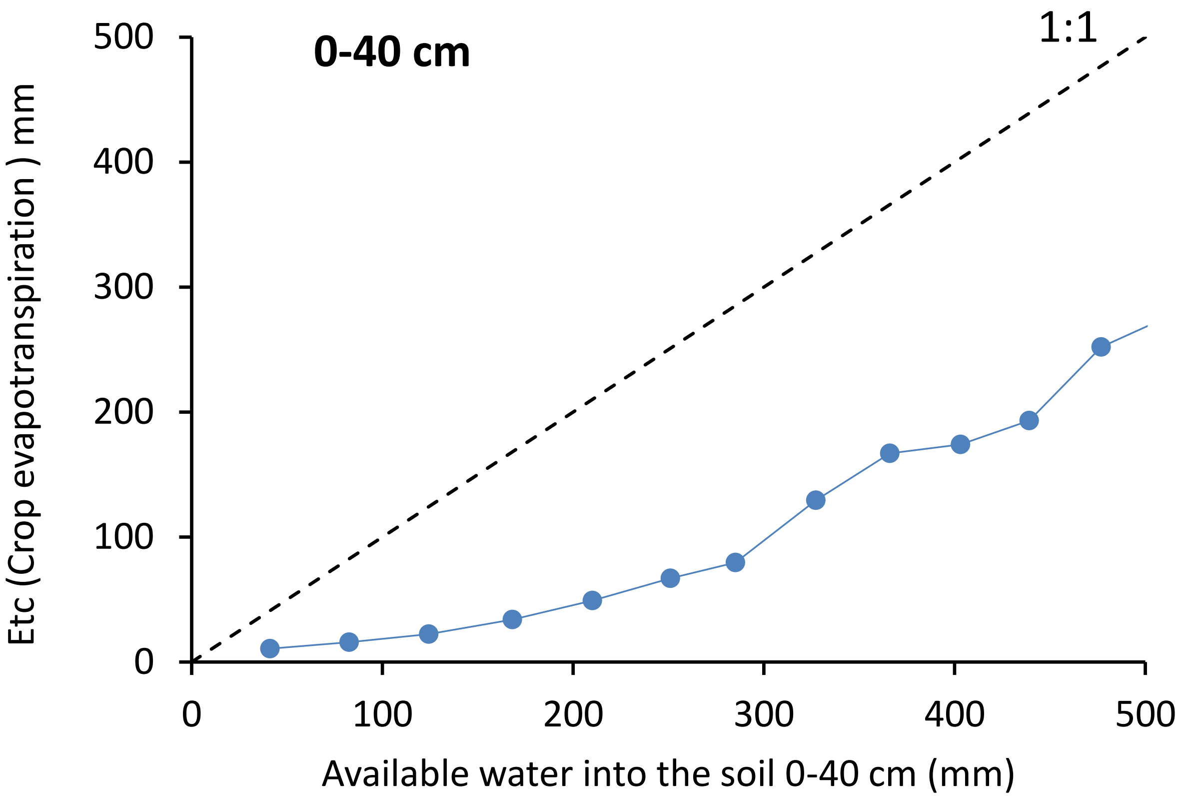
-Cumulative ETc was calculated around 300 mm



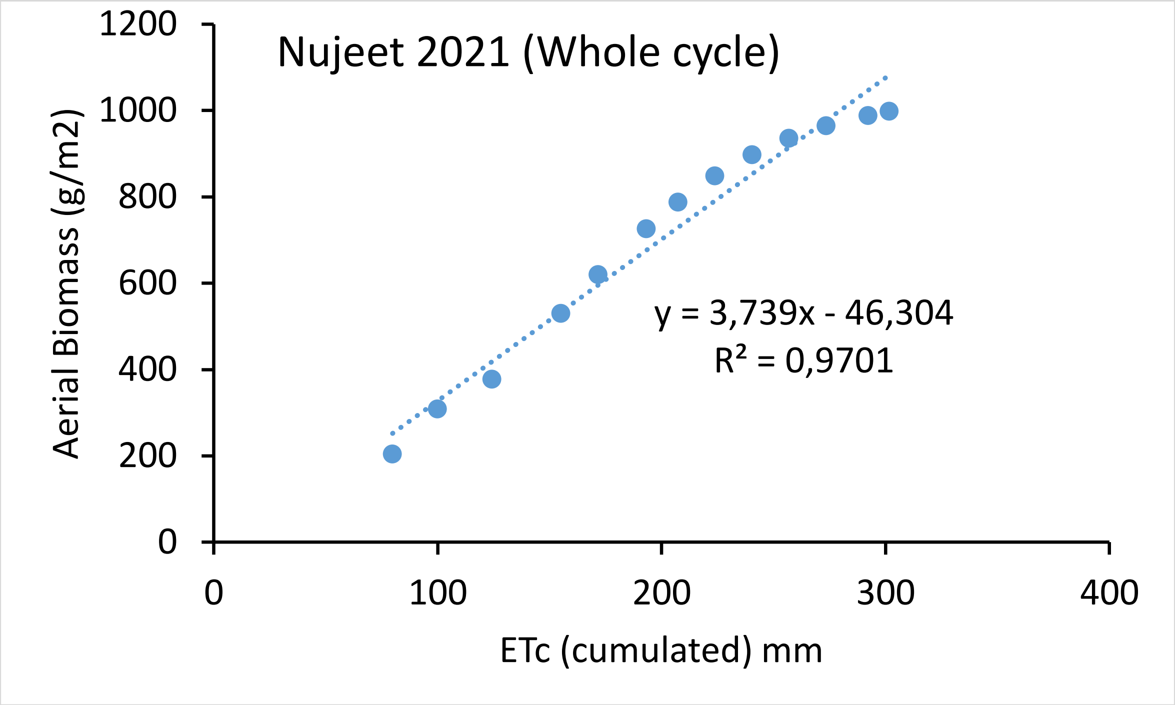


Crop Evapotranspiration (Etc) vs water availability in the soil



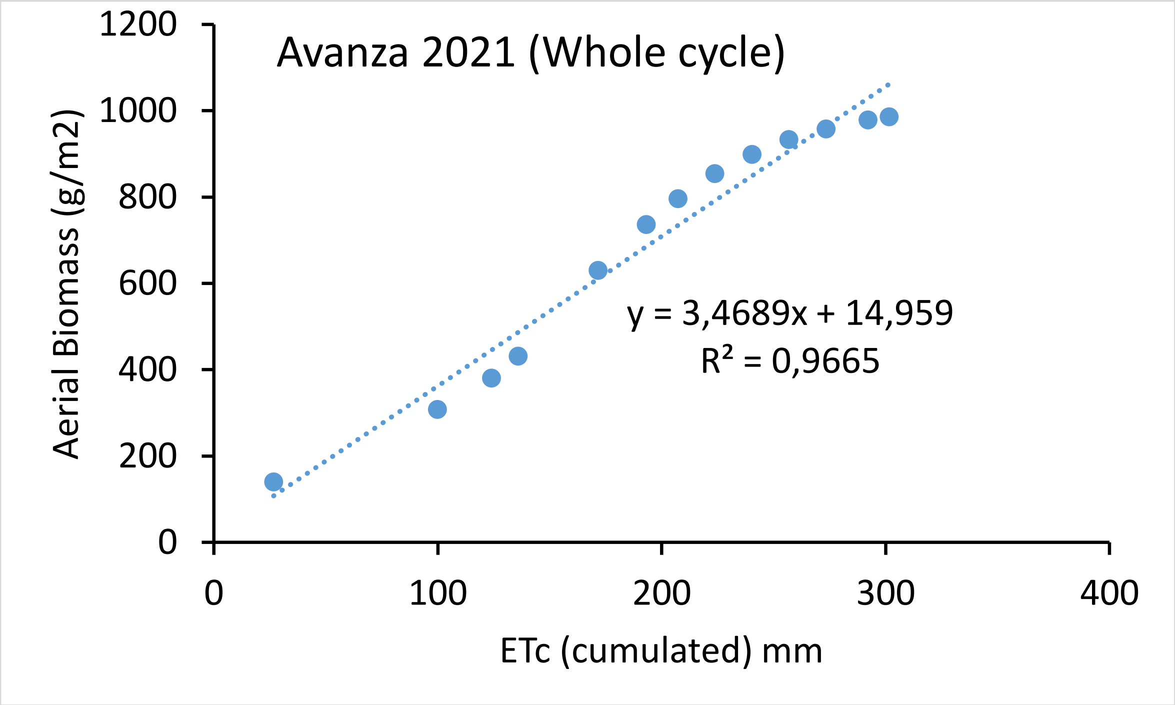


The comparison between ETc and available water into the soil showed that considering the soil depth from 0-20 cm water was enough during the first stages of the crop up to First Flowering but after that stage water availability in the first 20 cm was lower than the crop demand. However, when 0-40 cm was considered water availability was enough to satisfy the crop demand.



Water use efficiency for aerial biomass throughout the crop cycle

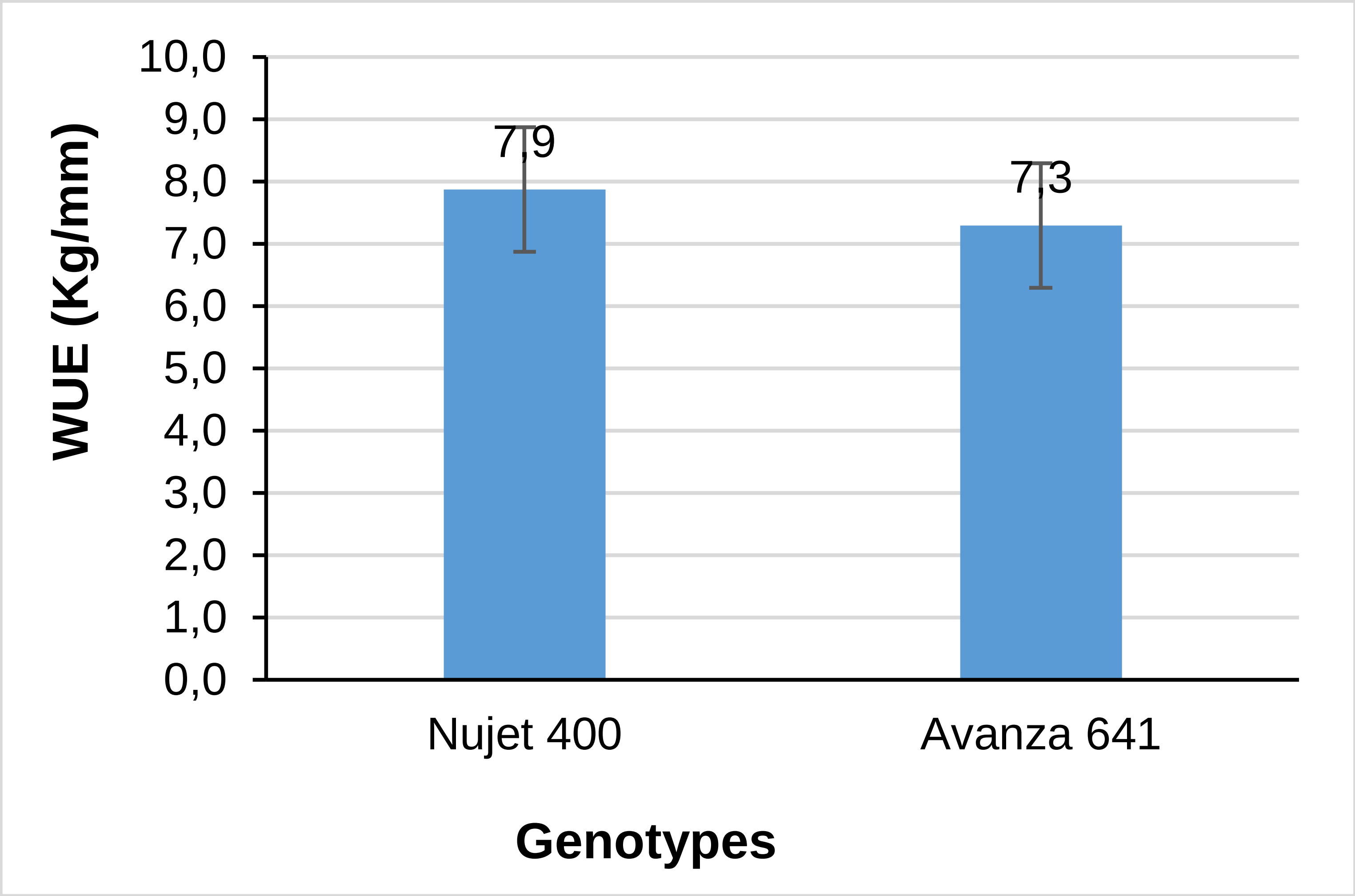
Aerial biomass accumulation modeled by a logistic model



Higher WUE during pre-flowering for Nujet 400

WUE Biomass (kg/ha/mm)	Nujet 400	Avanza 641
Whole cycle	37.4	34.7
Pre-flowering	**41.9**	25.8
Post-flowering	30.3	26.1

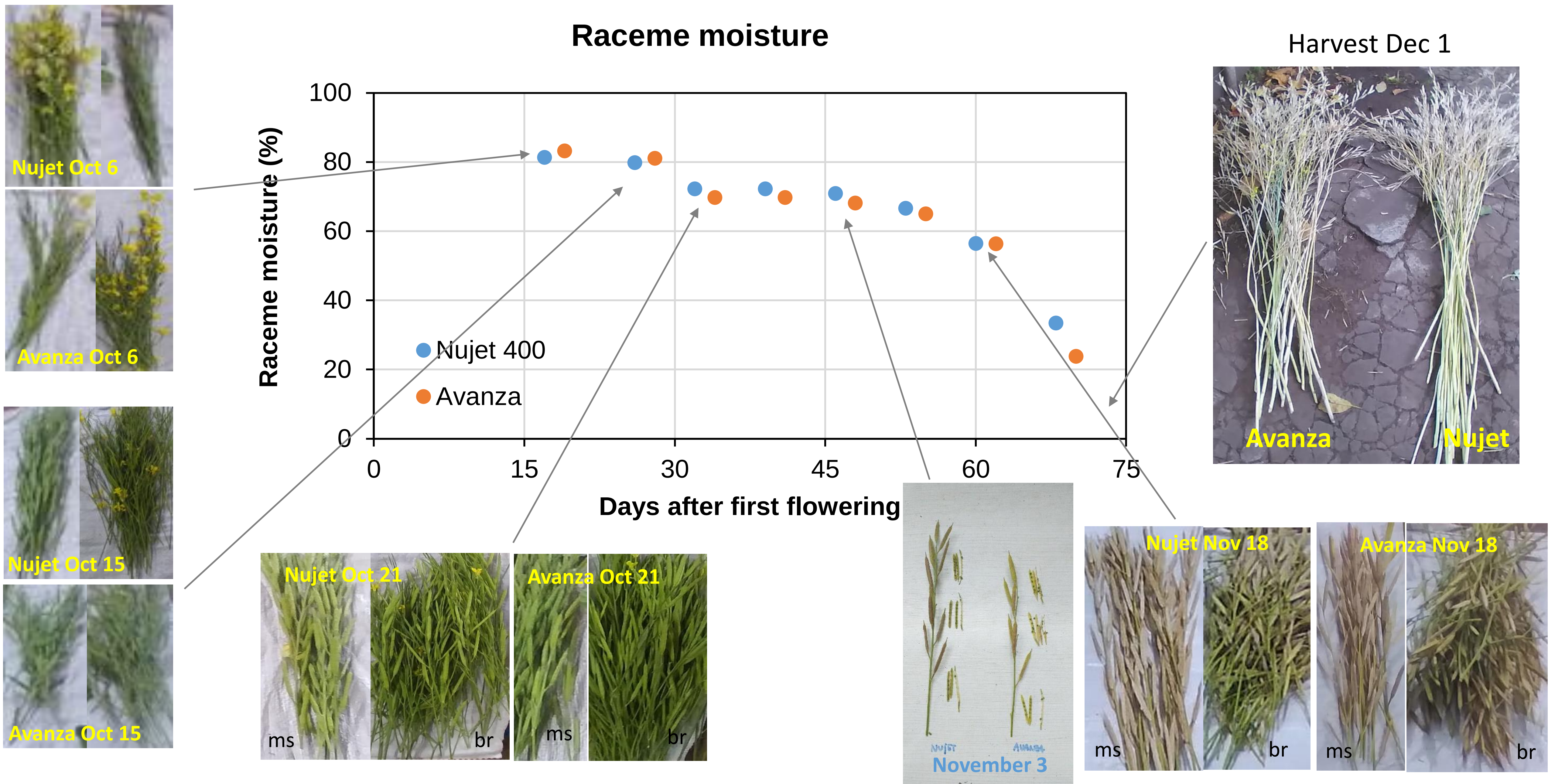
Water use efficiency for seed yield



WUE for seed yield was similar in both genotypes with values of 7.9 and 7.3 Kg/ha/mm (ETc) for Nujet and Avanza, respectively .

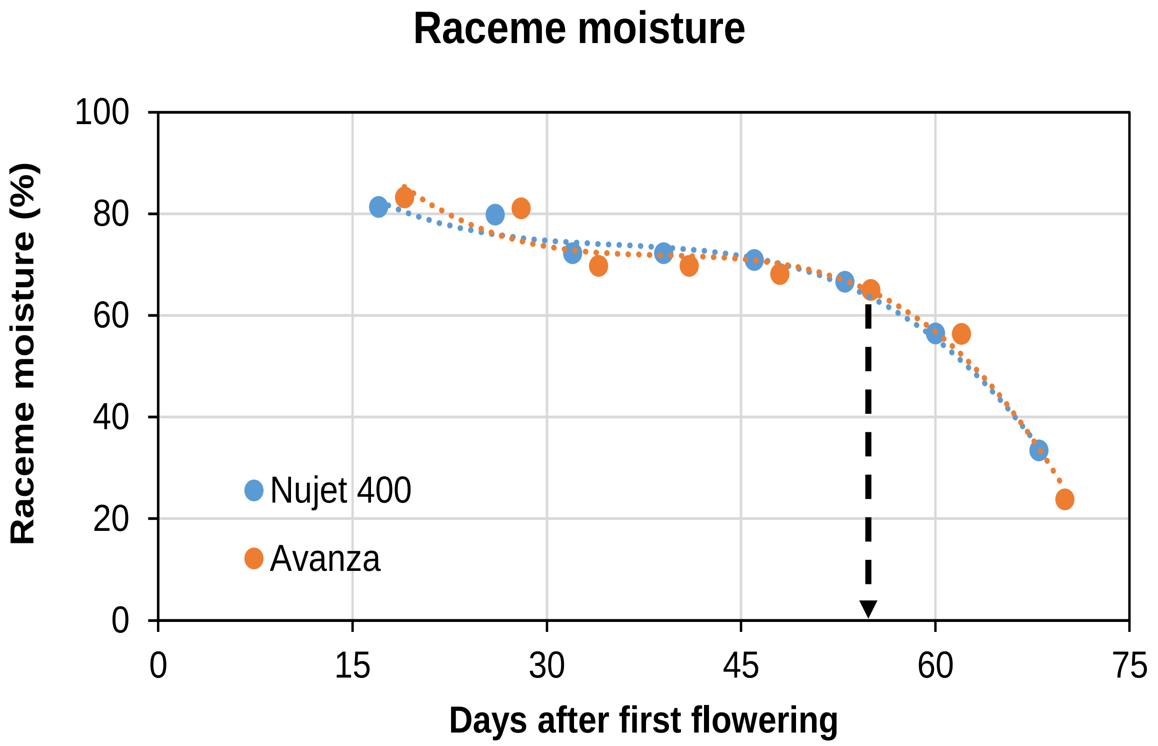
Values in the range of with Verma et al (2018) and Lal et al (2019) in B. carinata (5-10 kg/ha/mm) and Assefa et al (2018) and Kirkegaard et al (2021) in B. napus (7-15 kg/ha/mm)

Dynamics of raceme moisture

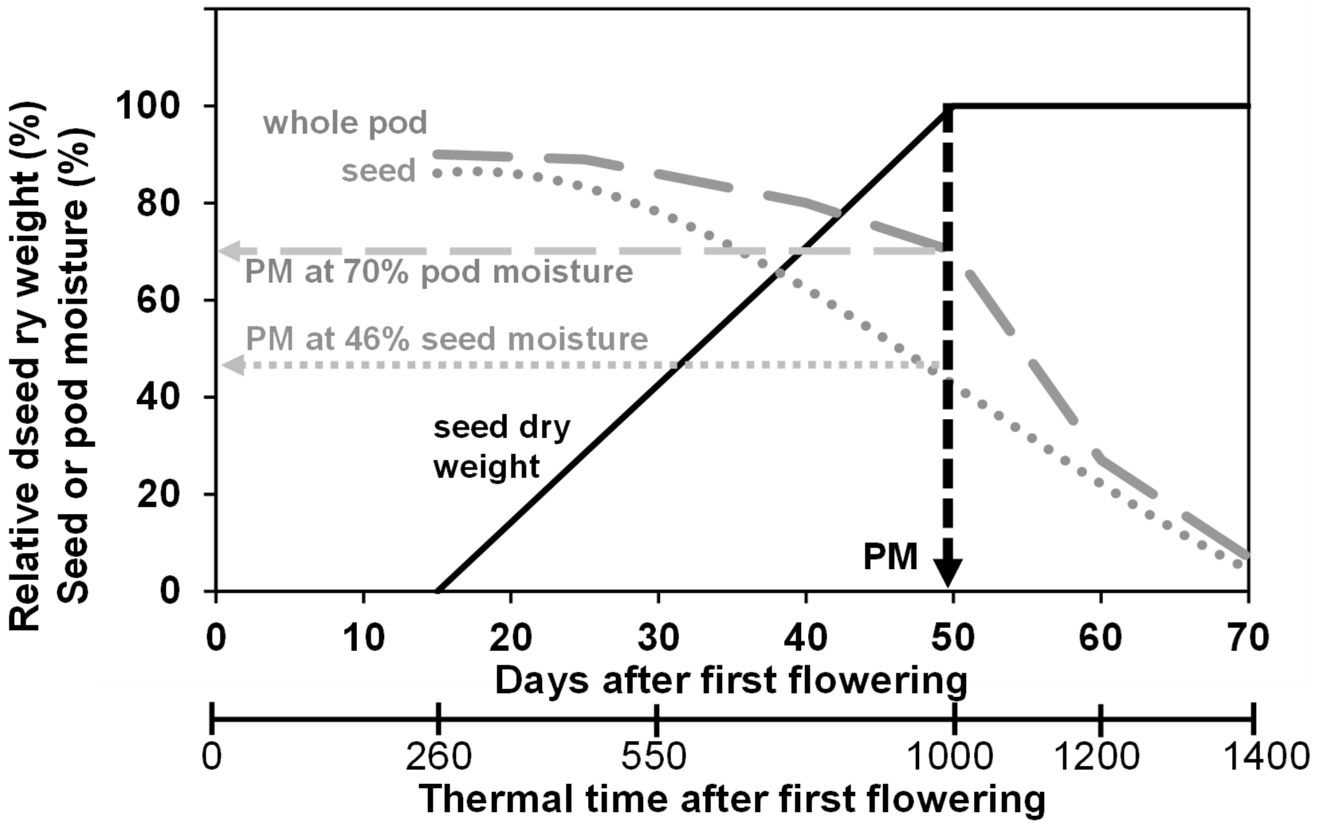


Dynamics of raceme moisture

-Carinata pattern very similar to canola
-Very moist racemes throughout post-flowering
-Fast drying from maturity (from Nov 11 onwards)



Canola: Pod moisture at PM



Menendez et al (2019) FCR

Crop harvest

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

3 m (0.6 m^2) from central rows were hand-harvested from different areas (covering natural plot heterogeneity).

Canopy structure at harvest

Five plants from each plot (25 plants in total for genotype) were randomly selected to measure canopy structure

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***
Number of primary branches (#/pl)	**5.7 ± 0.4**	**6.9 ± 0.3**	***0.0252***
Number of siliques from the main raceme (#/pl)	**16 ± 0.5**	**12 ± 0.4**	***0.0008***

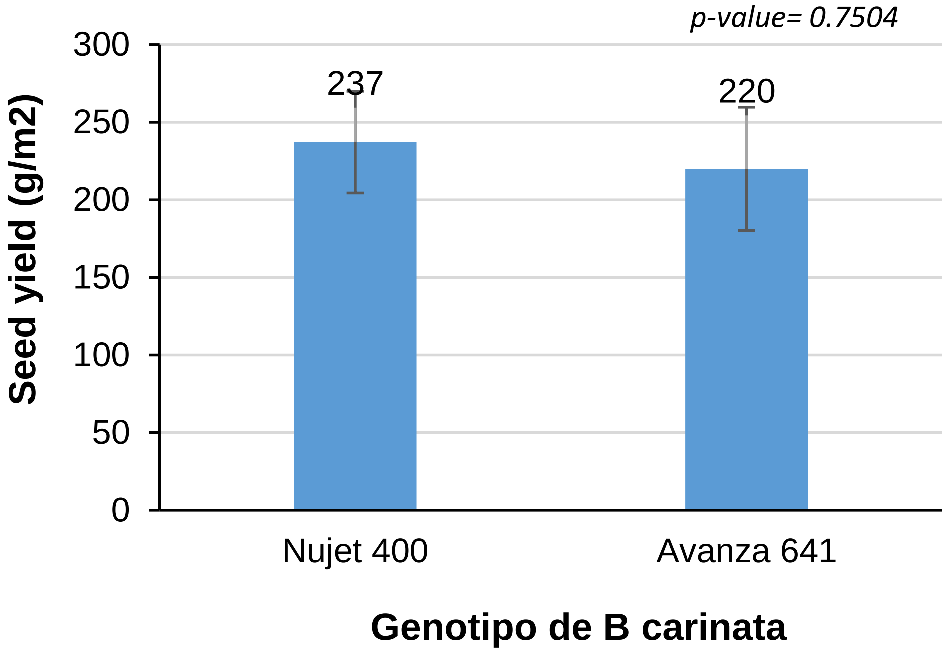
Nujet 400

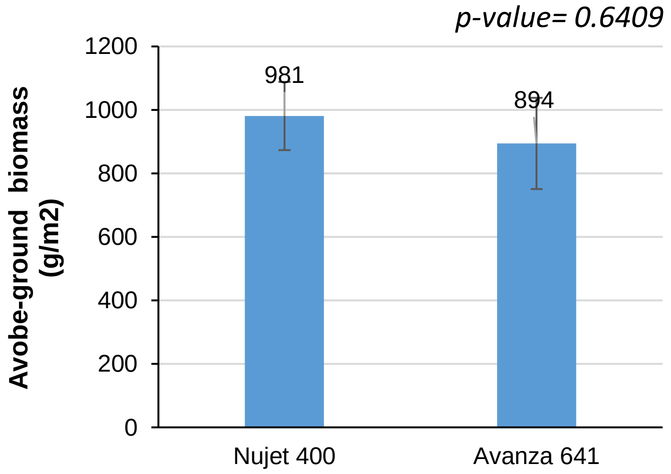
Avanza 641

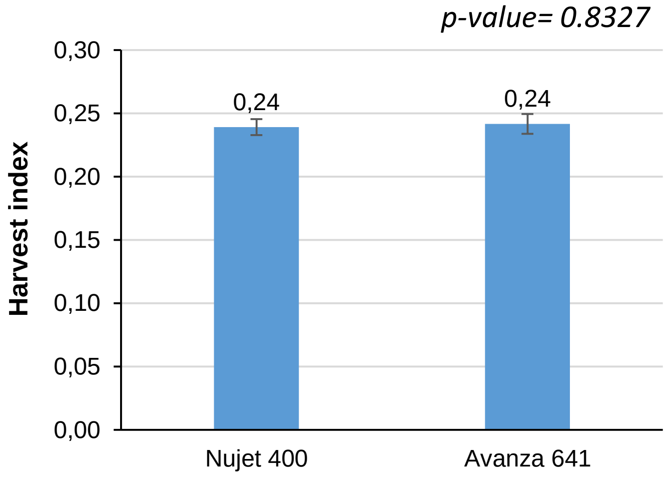
Nujet 400 had significantly more siliques on the main raceme, less branching, and the first siliques were located taller in the canopy respect to Avanza 641.

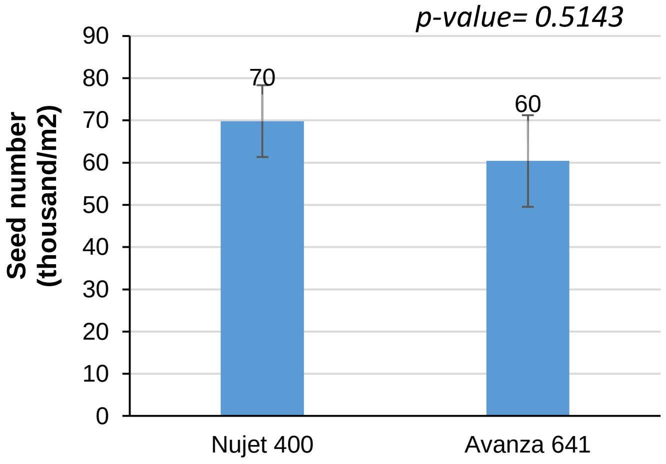
Seed yield and its components

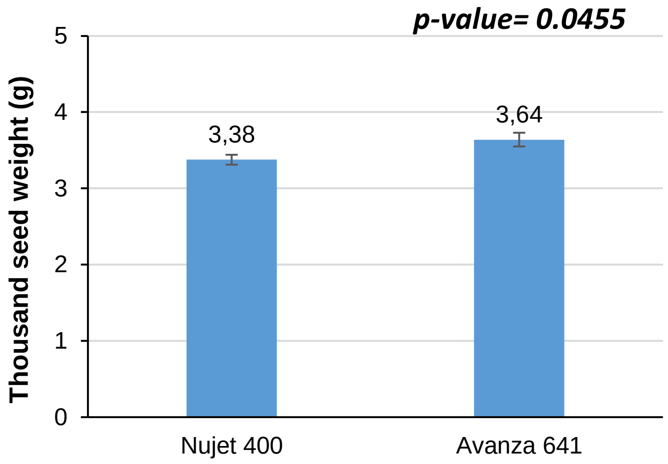
Biomass was dried, weighted, hand-threshed. TSW was calculated from 200-seeds aliquot











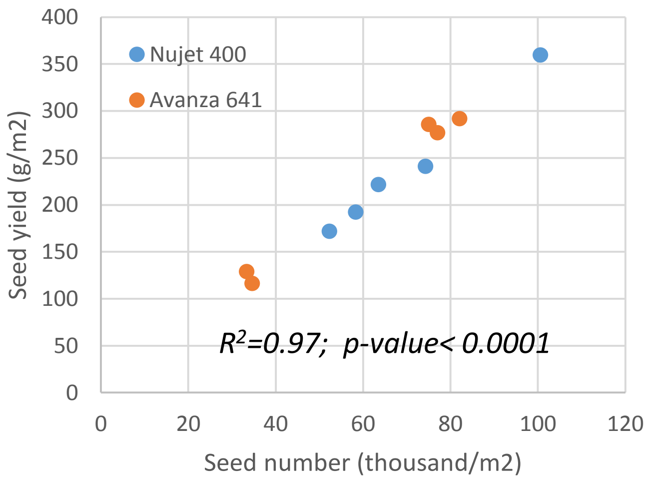
2200-2300 kg seed/ha (DW) similar in both genotypes. Avanza 641 had significantly heavier grains than Nujet 400

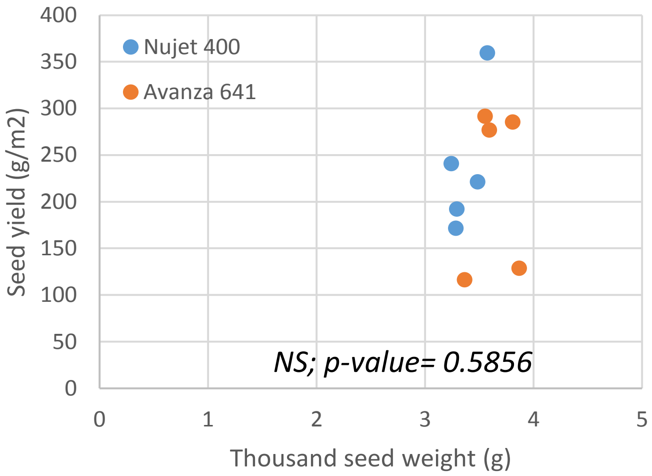
Harvest index (0.24) is in the lower range of B. carinata observed in USA (0.28-0.37) and Uruguay (0.23-0.34)

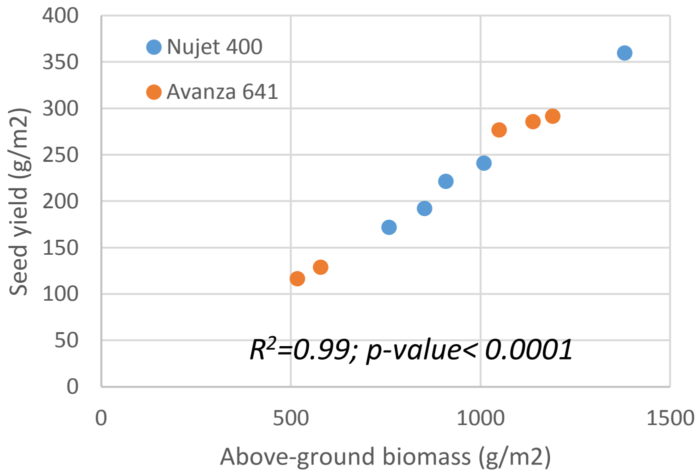
Seepaul et al. (2021); Mazzilli & Ernst (2020)

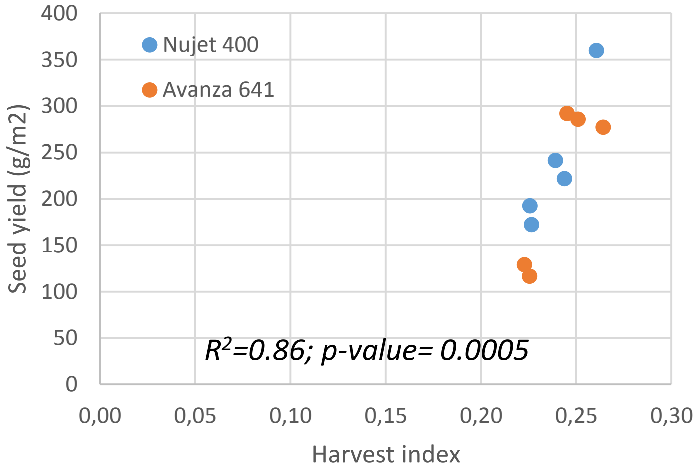
Seed yield and its components

-It was a high variability among plots (replicates n=5) in both genotypes (more than expected…)
-Seed yield range of 1200-2900 and 1700-3600kg/ha for Avanza and Nujet, respectively
-In line with seed yield range in Uruguay (2300-4800 kg/ha) Mazzilli (2020)







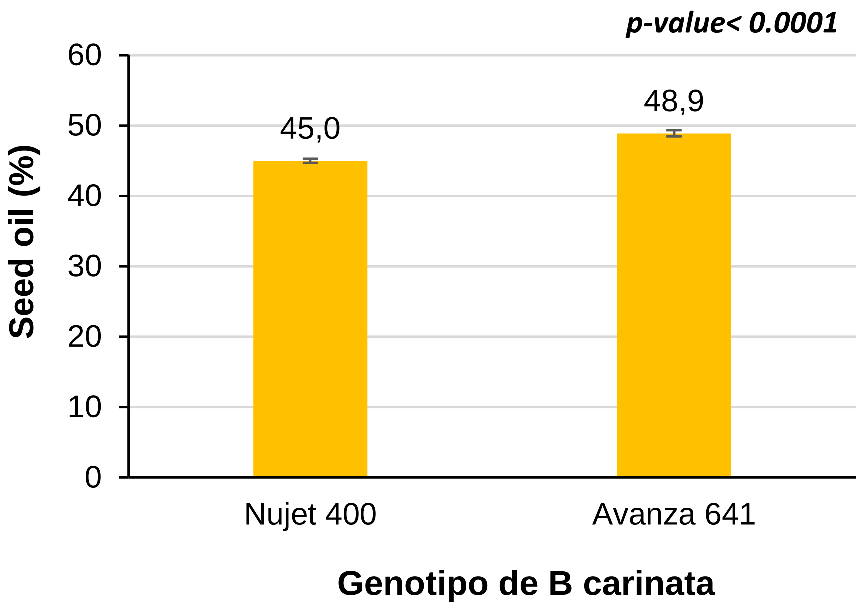


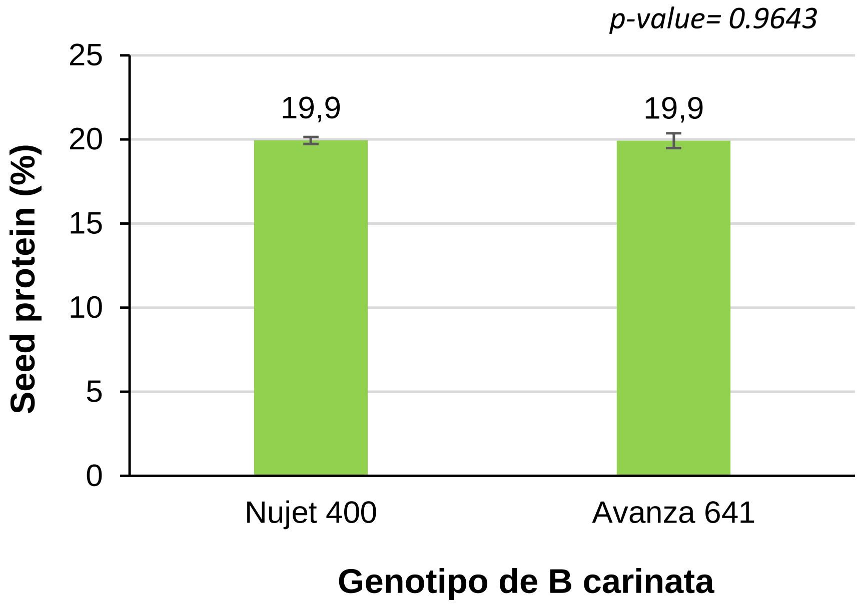
-As expected, seed yield was strongly and linearly associated with seed number,

-Also, seed yield was associated with both above-ground biomass and harvest index.

Seed composition

Oil was measured by Soxhlet (hexane extraction by 12 hs) and Protein by Kjeldhal (N x 6.25 protein) both expressed in dry weight.





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

Avanza 641has more seed oil than Nujet 400, with identical protein percentages.

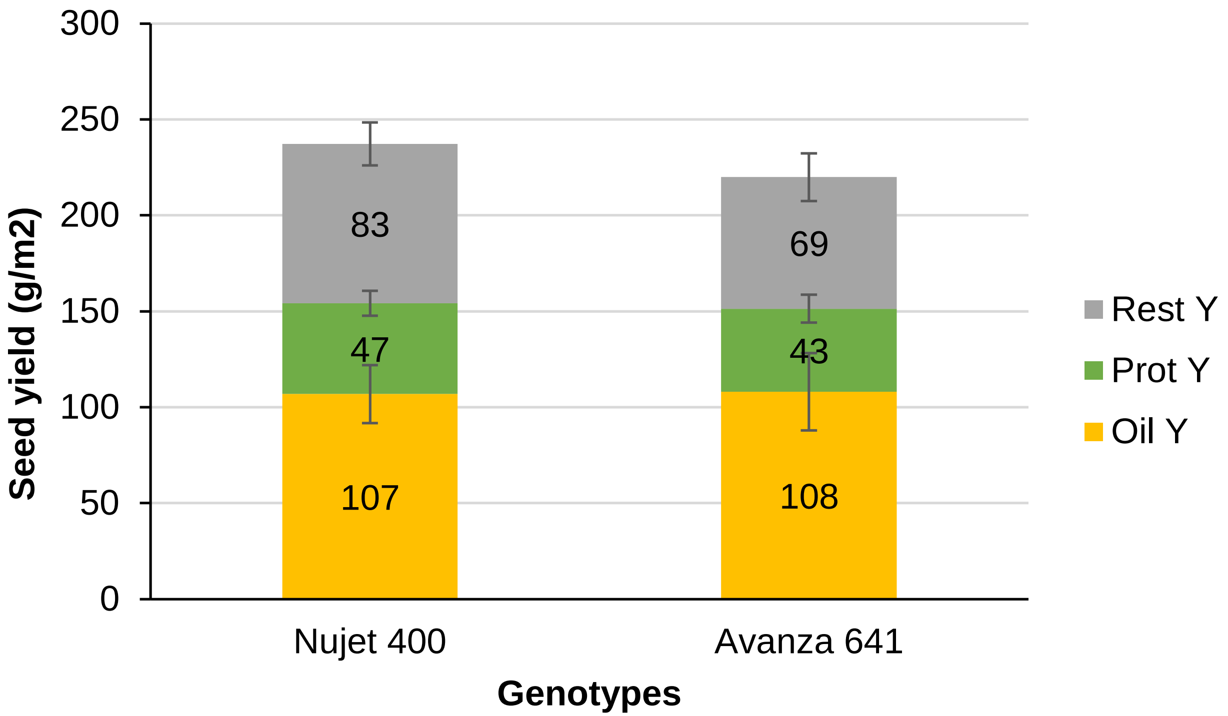
<u>Oil % are very high</u> compared to 39.7% reported in SE of USA (Seepaul et al 2021) and 42% in India (Lal et al 2019)

Protein % is less than 22-31% reported in USA and India

Seed composition is in the range of canola in Buenos Aires (37-51% oil; 16-24% protein) Rondanini et al. (2017)

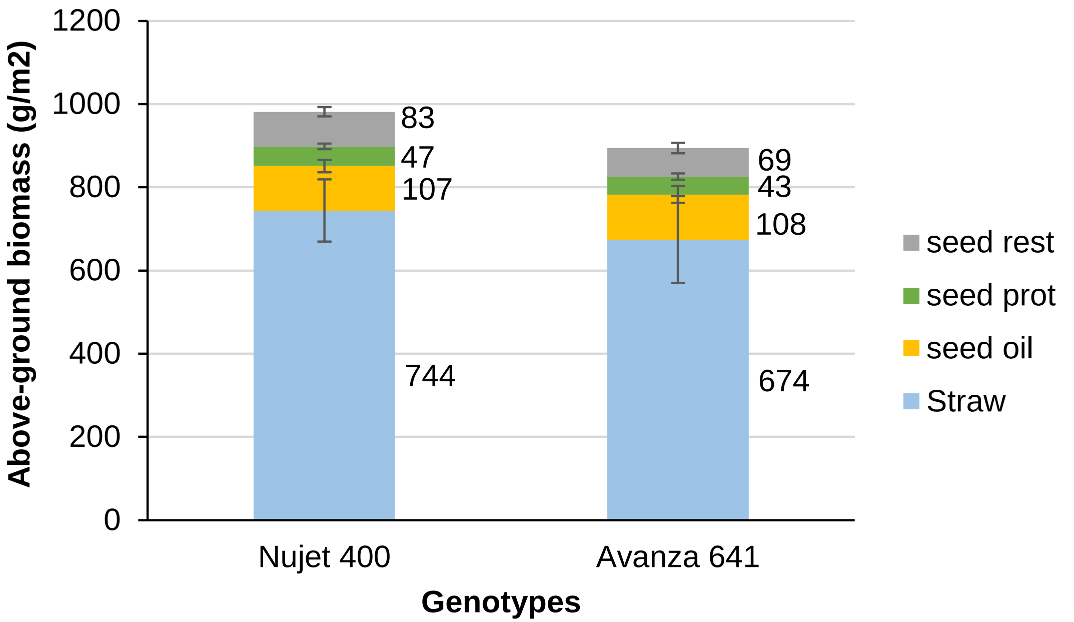
B. carinata productivity

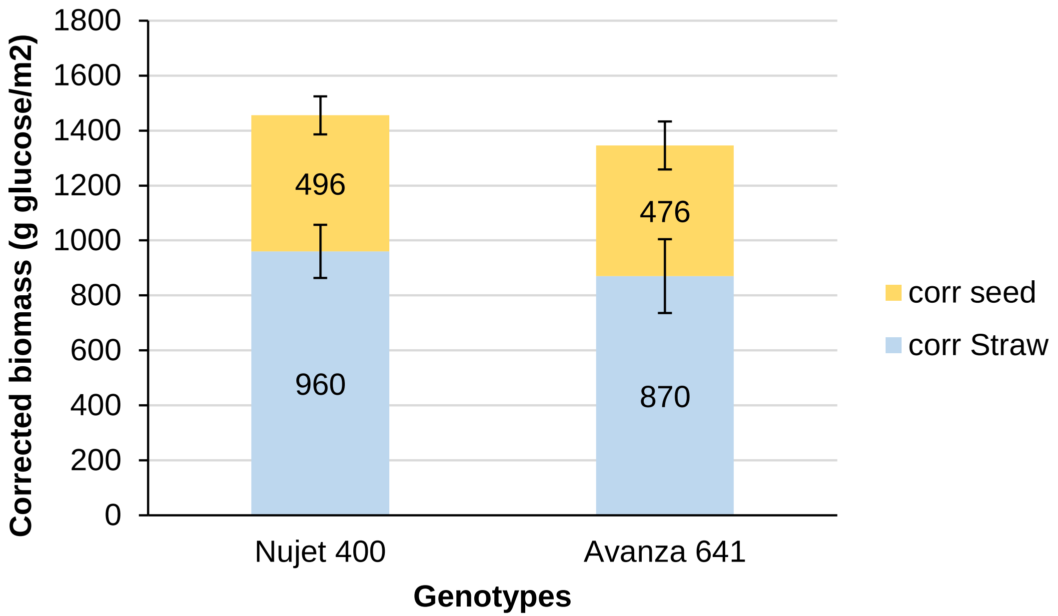
Average oil yield (**1070 kg oil/ha**) and protein yield (**450 kg protein/ha**) did not differ significantly between genotypes



p-value Oil yield= 0,962
p-value Protein yield= 0,6913
P-value rest of grain yield= 0,4149

Aerial biomass productivity <u>corrected by energetic cost</u>





P-value corrected seed = 0.8575
P-value corrected straw = 0.6014

<u>Assumptions</u>: straw biomass is mainly carbohydrates with 10% of lignin (Wassner et al 2020); and seed biomass corrected by oil and protein (% measured). Grams of glucose equivalent per gram of compound are considered according to Penning de Vries et al (1983).

14,560 and 13,460 kg glucose per ha

P-value corrected above-ground biomass = 0.7055

Soil organic matter after harvest

-At 15 days after harvest, aerial biomass (straw) was cut with a mechanical mower, remaining on the surface, without tillage.
-At 30 days after harvest, soil was sampled (0-20 m deep) from the middle of each plot and sent to external lab for determining the content of particulated organic matter (newly incorporated organic matter).

Particulated organic matter (%)	
Nujet 400	**Avanza 641**
0.33	**0.26**

Values are in line with soils under several years of agriculture (< 0.5%). The particulated organic matter is a short-term source of N because of the rapid mineralization, and is largely related with higher yields of crops (Dominguez et al., 2006; Imbellone et al. 2010 INTA; Sainz Rozas et al 2011 IPNI).

Section B

Brassica carinata phenology by sowing dates

CRONOCARINATA: A simple model for predicting phenology

Six different sowing dates from May to August

Experiments at the School of Agriculture, University of Buenos Aires (34°36'S 58°26'W) Plant density:80-100 pl/m2, watered and fertilized (100 kg N/ha)

12/5/2021	SD1
1/6/2021	SD2
23/6/2021	SD3
16/7/2021	SD4
29/7/2021	SD5
20/8/2021	SD6

Phenological stages determined throughout the crop cycle in Nujet 400 and Avanza 641

Crop Stages: Sowing, Emergence, vegetative stage of Rosette (4 emerged leaves – V4), Visible Floral Bud, First Flowering, First Fruiting , Green grains, Colored Grains and Maturity, according to CETIOM scale for canola (Arnoud 1989)

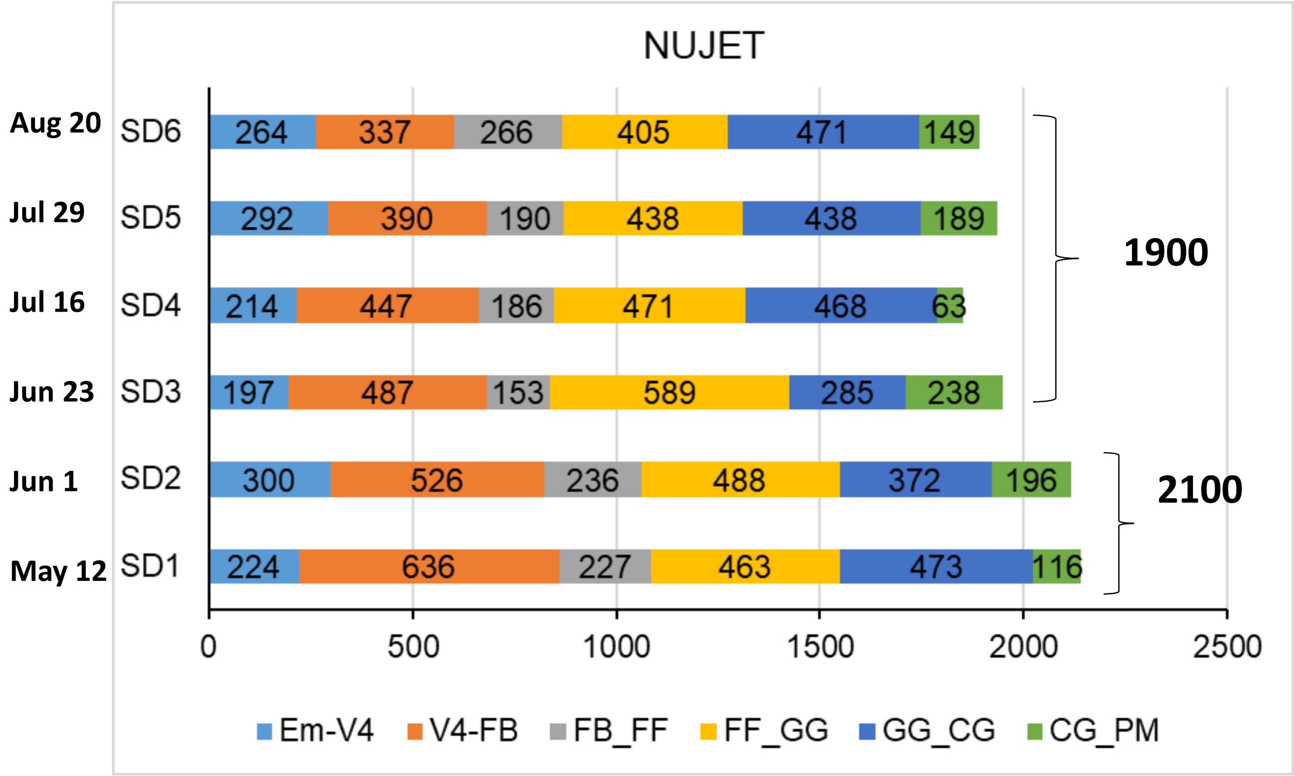
Em **V4** **FB** **FF** **FFr** **Firm Green grain** **Coloured grain**

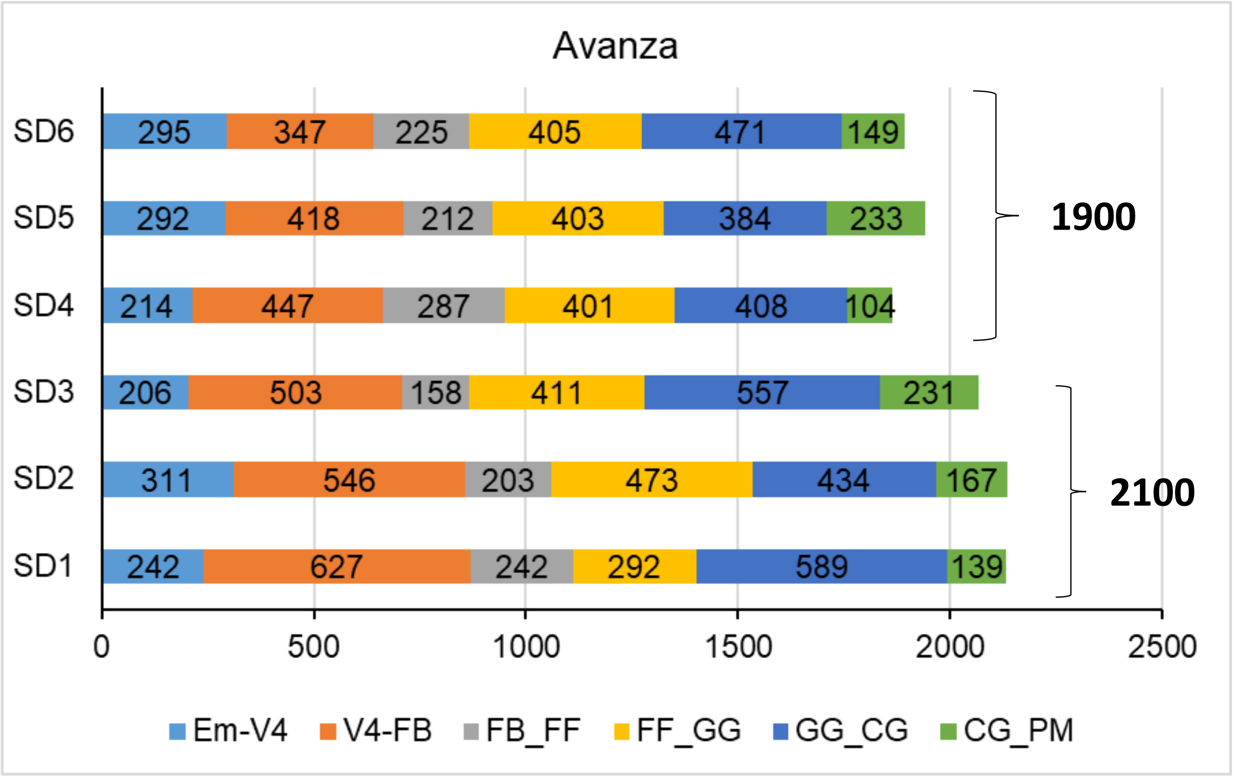
As mustard seed color is light yellow, ‘coloured grain’ stage is a bit difficult to distinguish

Duration was measured in calendar days and thermal time (degree days - °Cd) using a base temperature of 0°C

Other authors use Tbase 4-4.5 (Seepaul et al. 2021) but Mazzilli didn’t find differences using 0 in Uruguay

Crop phenology by sowing dates





-The duration of the cycle (in thermal time) was shortened as sowing dates was delayed

-Both genotypes had very similar crop development

V4 rosette (relevant for frost tolerance)

Heladas Meteorológicas (0 ºC)

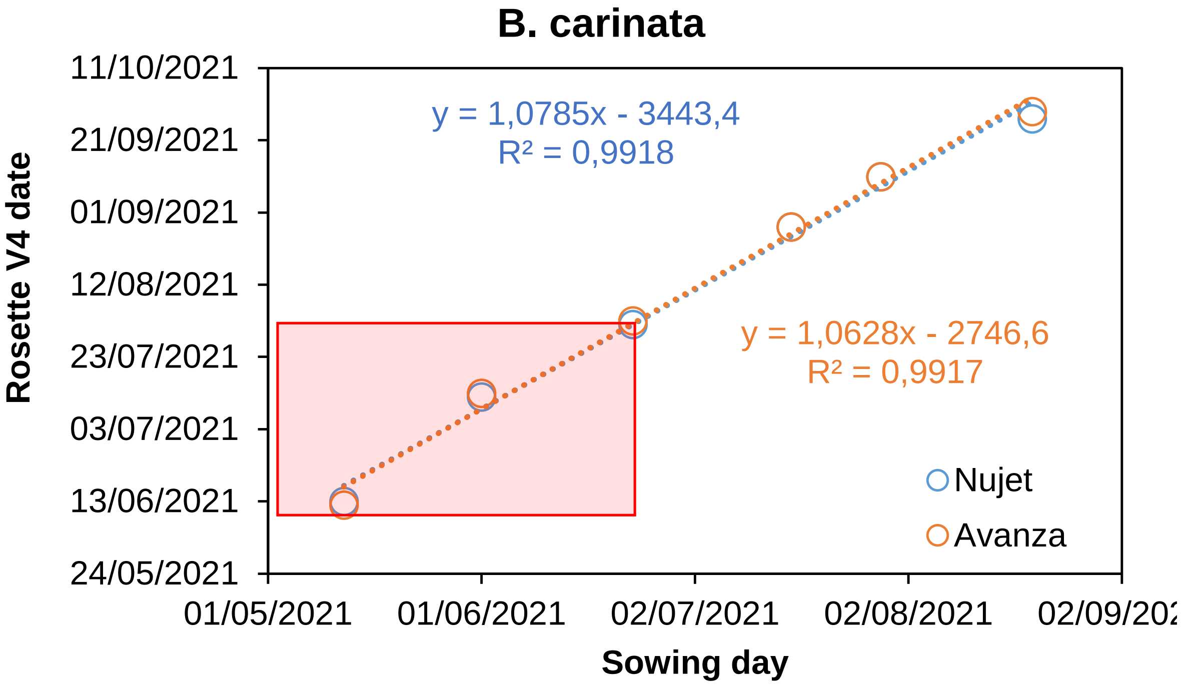
Buenos Aires OBS.		
	FPH	FUH
Valores medios	7-jul	15-jul
Desvío estándar	15	14
Valores con probabilidad (20 %):	11-jun	2-ago
Extremos	18-may	2-sep

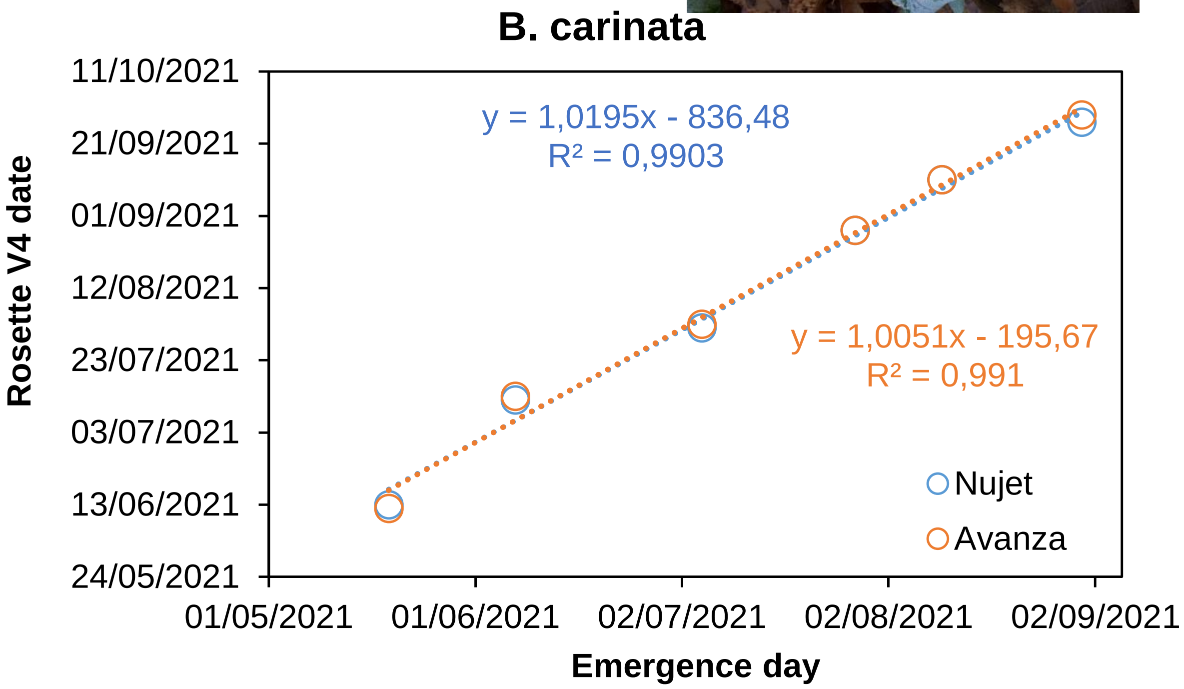
-By delaying the sowing date, the V4 stage was from **June 13 to September 29**

-Frost risk >20% in Buenos Aires (from June 11 to August 2)

-V4 is delayed proportionally to the sowing or date (slope 1)

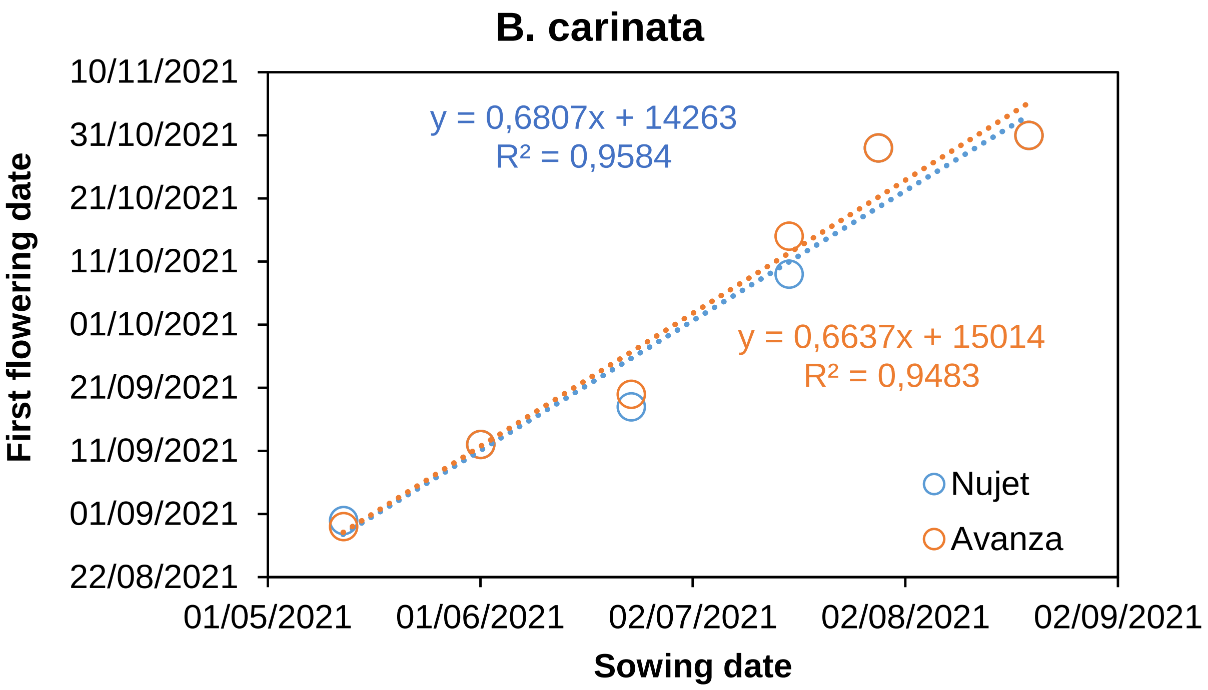
Frost on July 3 in SD1
(no foliar damage was observed)

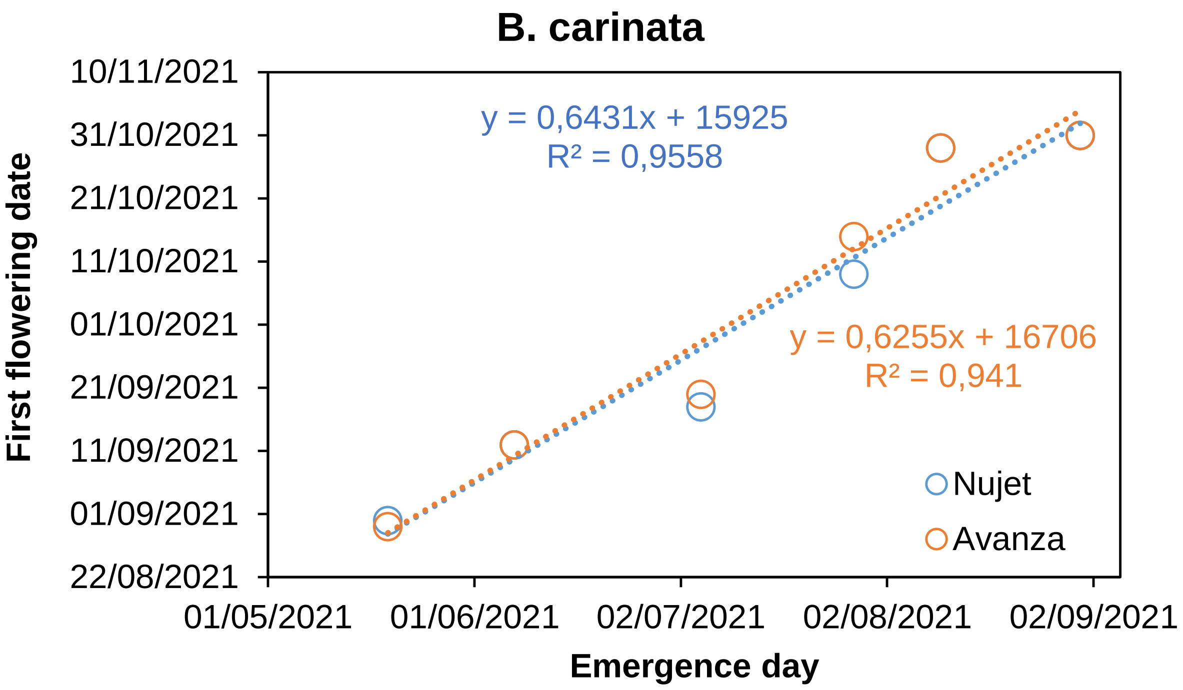




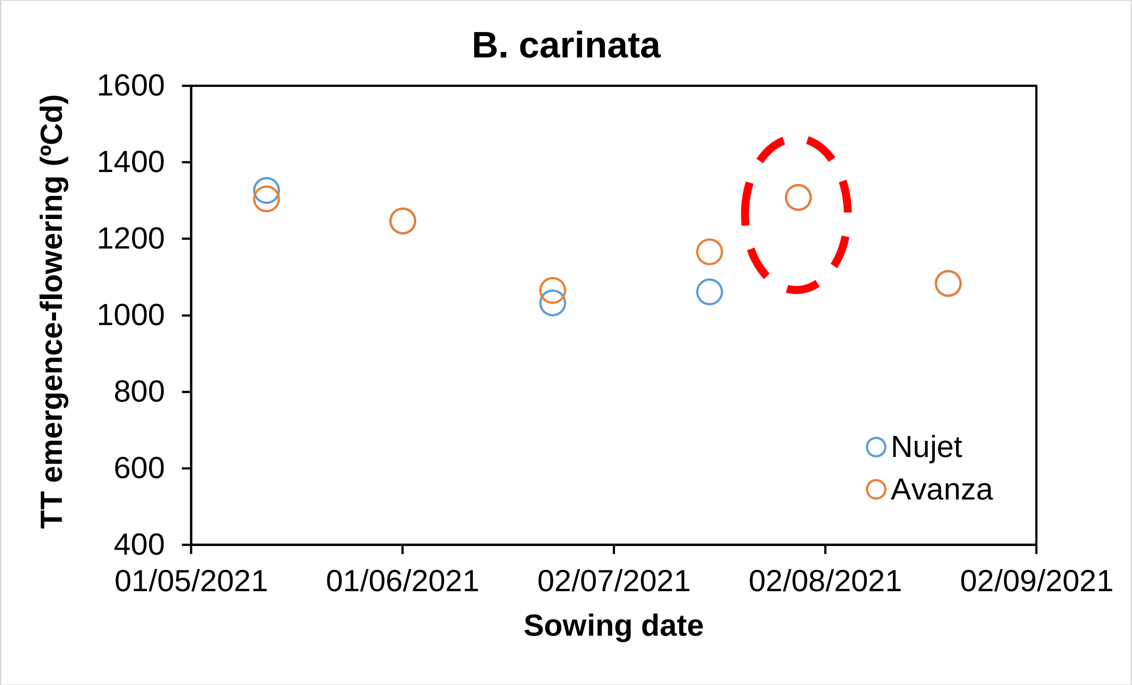
Flowering date

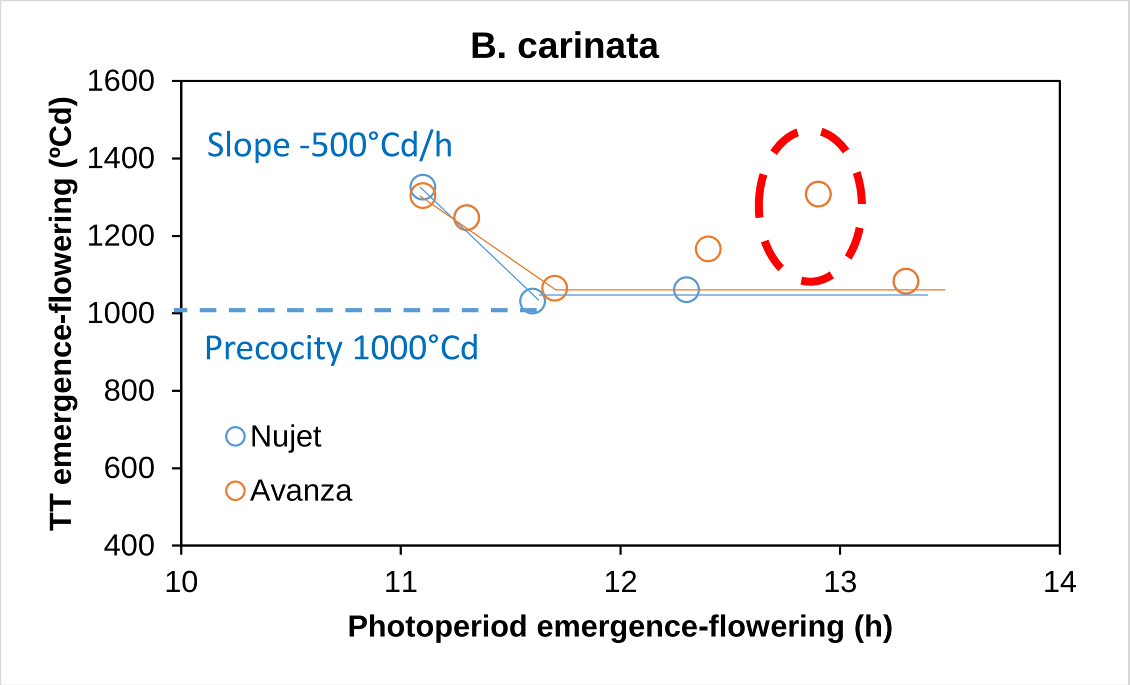
-First flowering was from **August 30 to October 31** across sowing days
-There is no risk of frost in flowering for these dates in Buenos Aires
-On average, flowering is delayed one week for every 10 days of delay in the sowing date





Flowering response to photoperiod





-Abnormal behavior for sowing date of July 29 in both genotypes (long duration of the flower bud-flowering stage, with high mean temperatures >25°C prior to flowering)

Photoperiod threshold: around 11.5 h (similar to spring canola)
Precocity: around 1000°Cd
Photoperiodic sensibility: <u>around -500°Cd/h</u>

Carinata precocity similar to short-cycle bread wheat (for example Baguette 450 and DM Ceibo) but twice photoperiodic sensitivity of wheat (220-370°Cd/h Jardon et al 2022).

Comparing phenology with Uruguay

Data from Buenos Aires (Lat: 34°S) compared with Paysandú, Uruguay (Lat: 32°S)

Critical period for seed yield (100-400ºCd from first flowering)

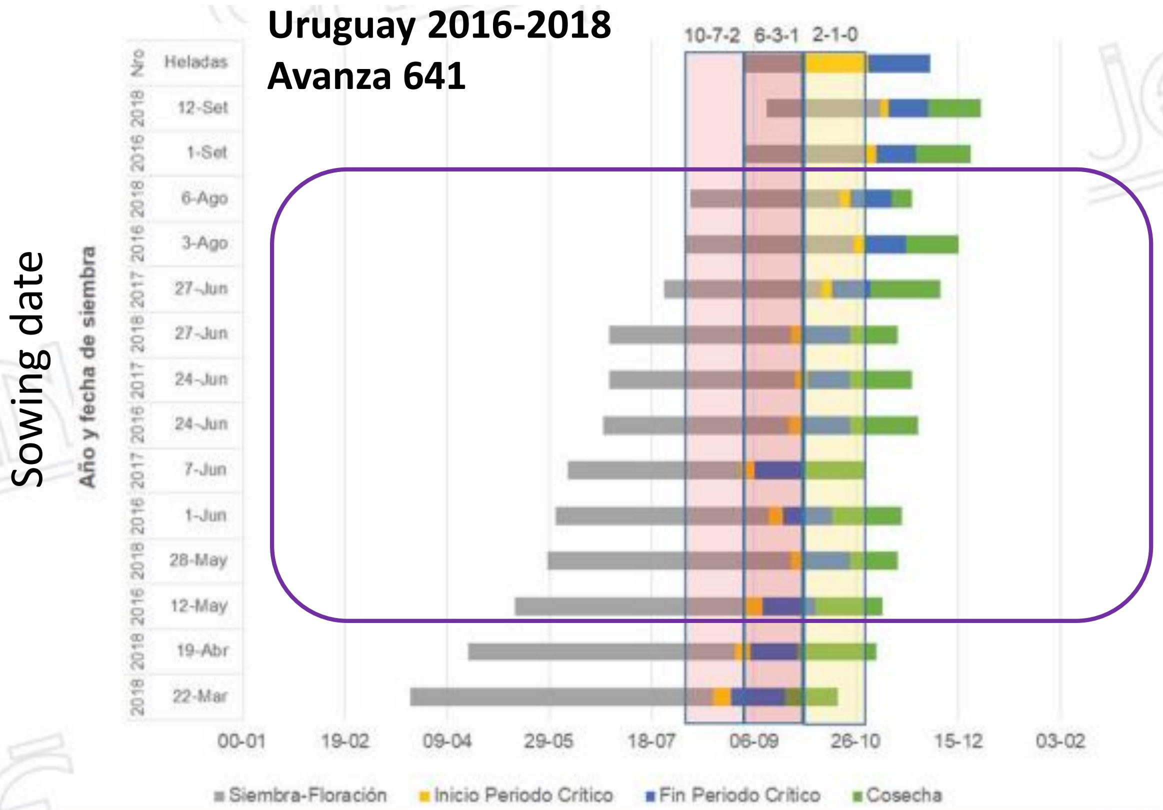
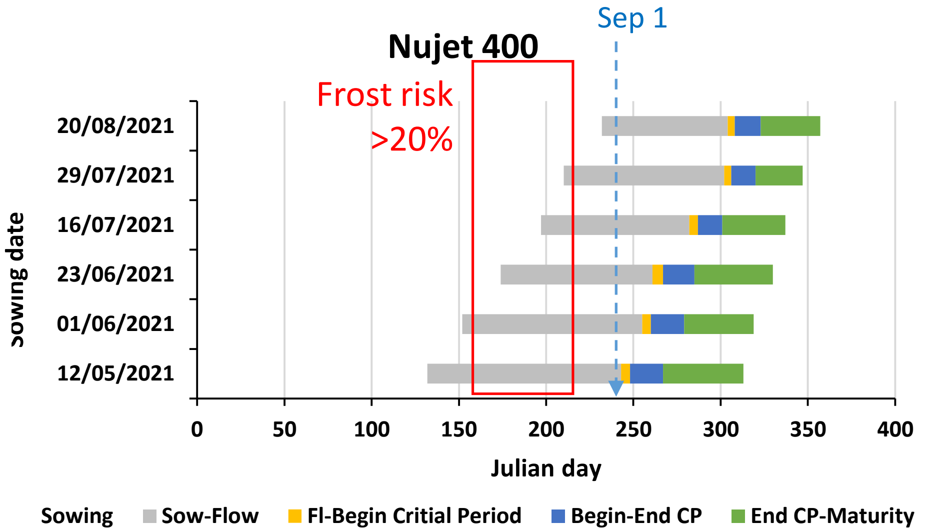
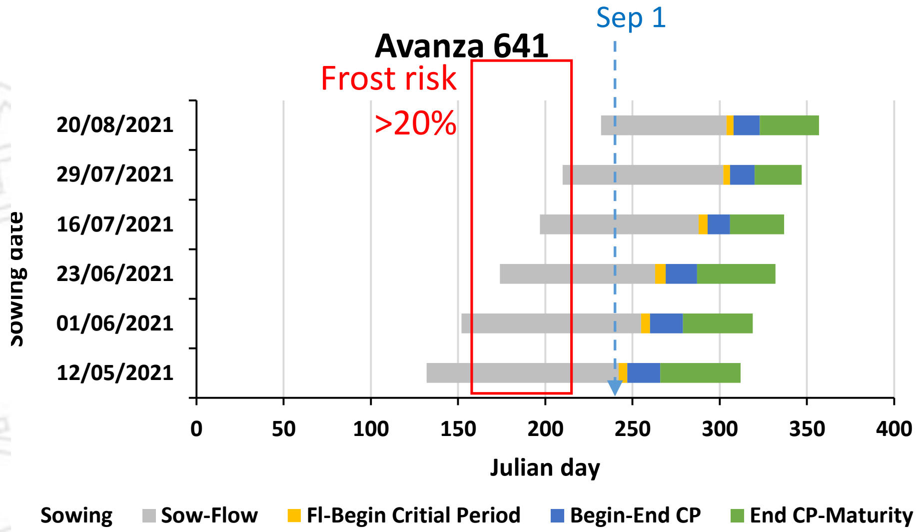


Figura 3. Ubicación del periodo crítico de determinación del rendimiento (Kirkegaard *et al.*, 2018) (100 a 400 °C día luego de inicio de floración) y riesgo de heladas en floración y periodo crítico según fecha y año de siembra para la zona de influencia de la EEMAC. Cada barra vertical indica el mes (agosto, setiembre y octubre) y los valores arriba de la barra indican el número esperado de heladas según el percentil (P) evaluado (P10-P50-P90) obtenido de INIA GRAS (http://www.inia.uy/gras/Clima/Caracterizaci%C3%B3n-agroclim%C3%A1tica/Heladas).

Mazzilli (2020)

Buenos Aires 2021





Comparing phenology with Uruguay: response to photoperiod

Uruguay
Avanza 641

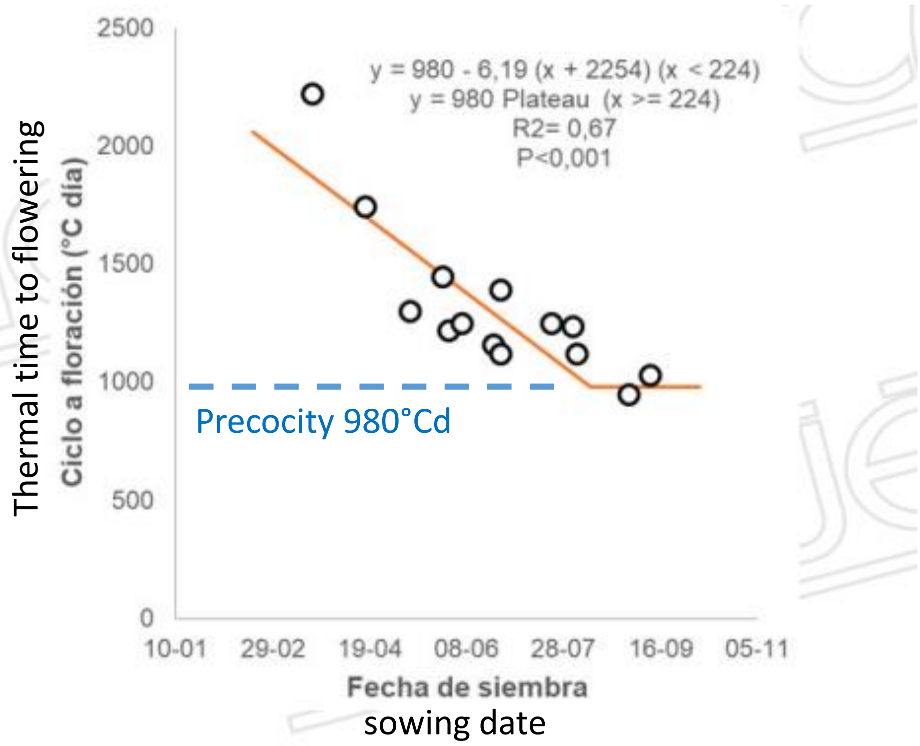
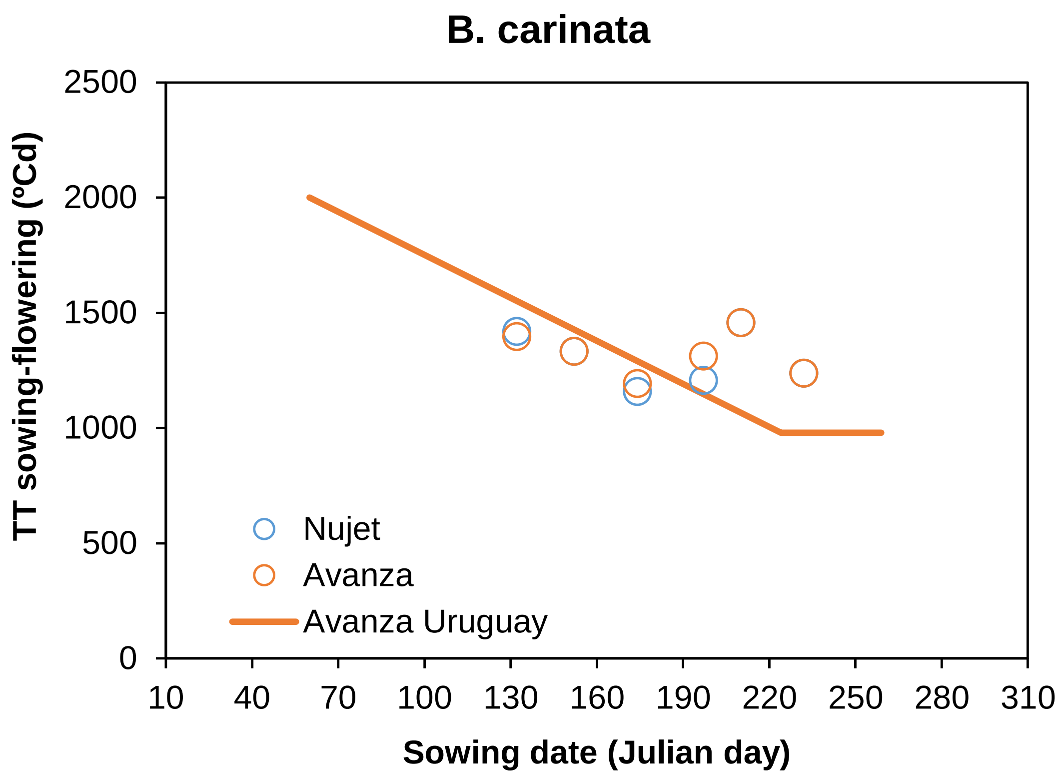


Figura 2. Duración del ciclo a floración según fecha de siembra.

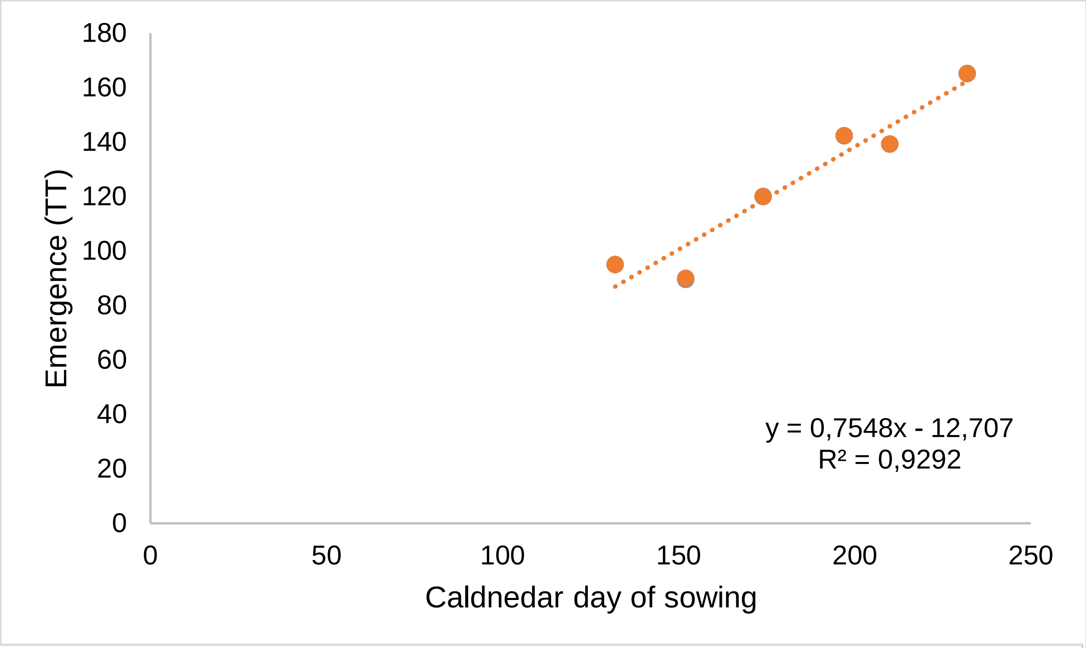
Mazzilli (2020)

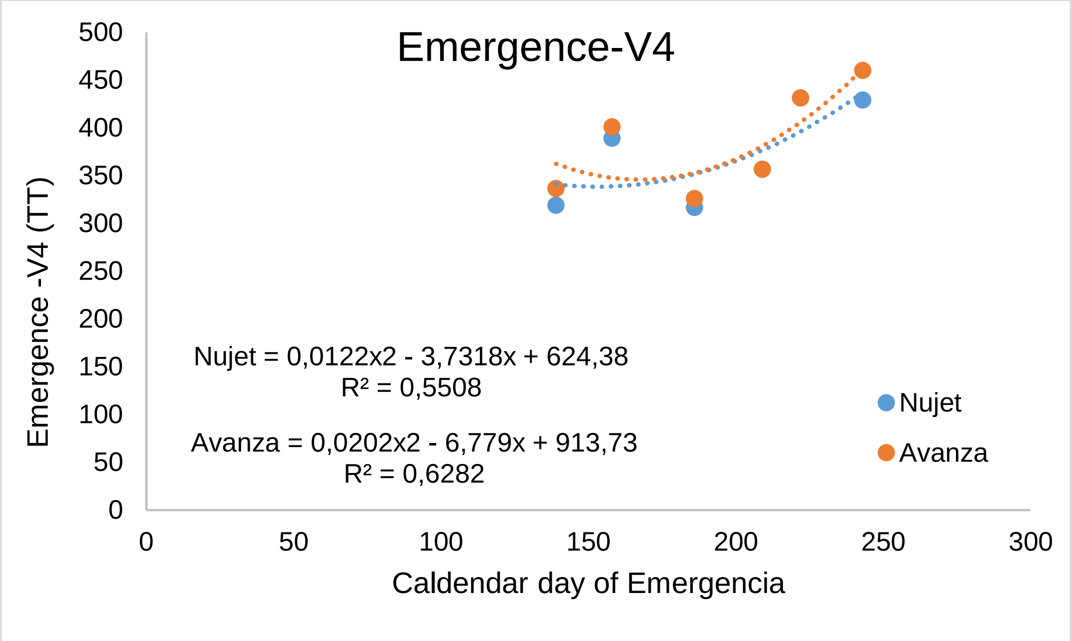
Buenos Aires 2021



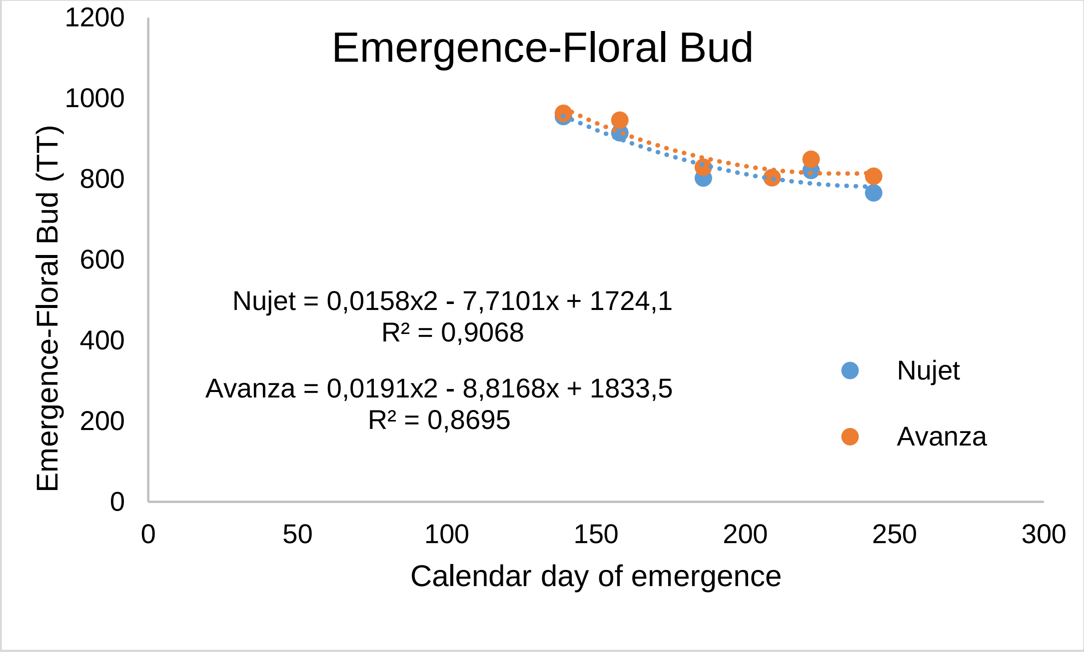
- Similar pattern for long-day response
- High variability for sowing dates after July
- A broader framework of planting dates is needed in Buenos Aires 2022

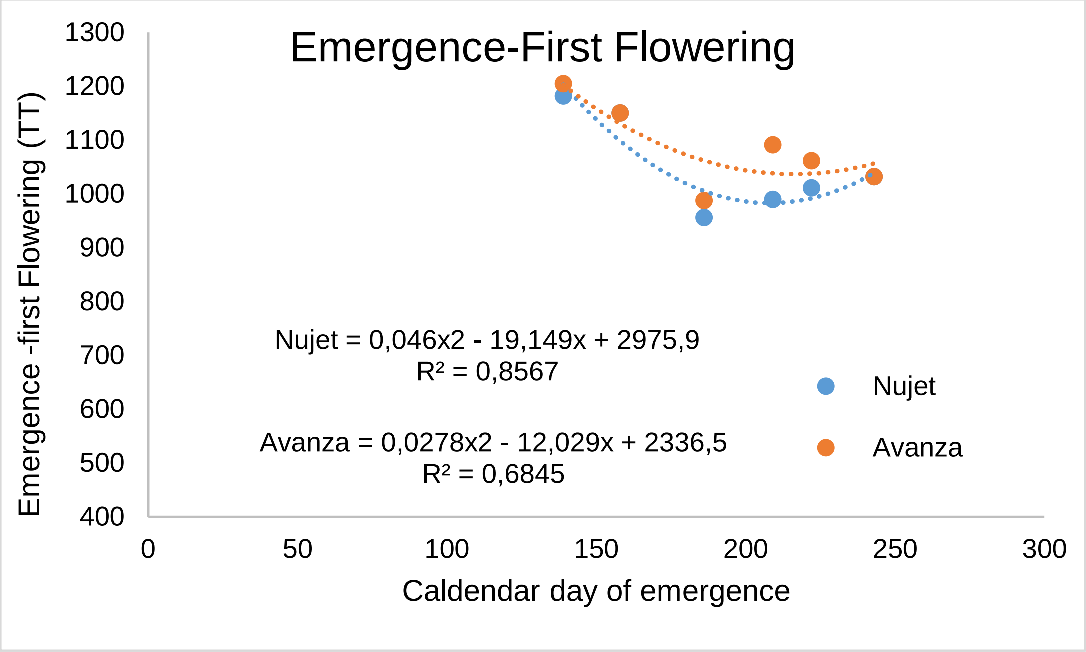
Algorithms for the Cronocarinata model





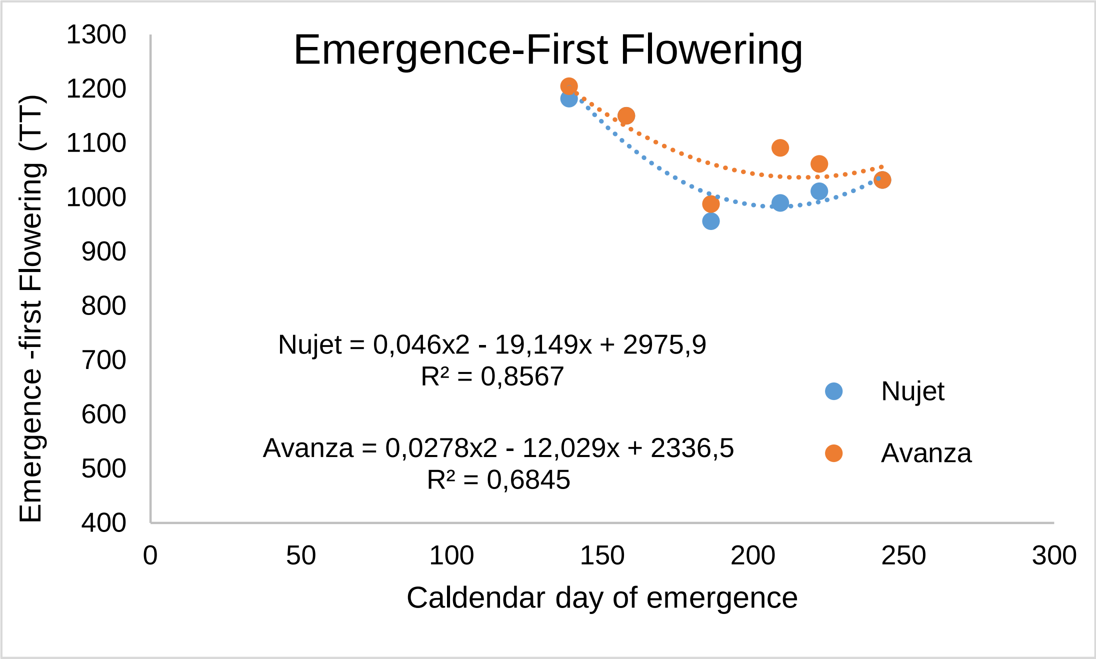
Unexpected for photoperiod long-day response (other tbase? vernalization?)

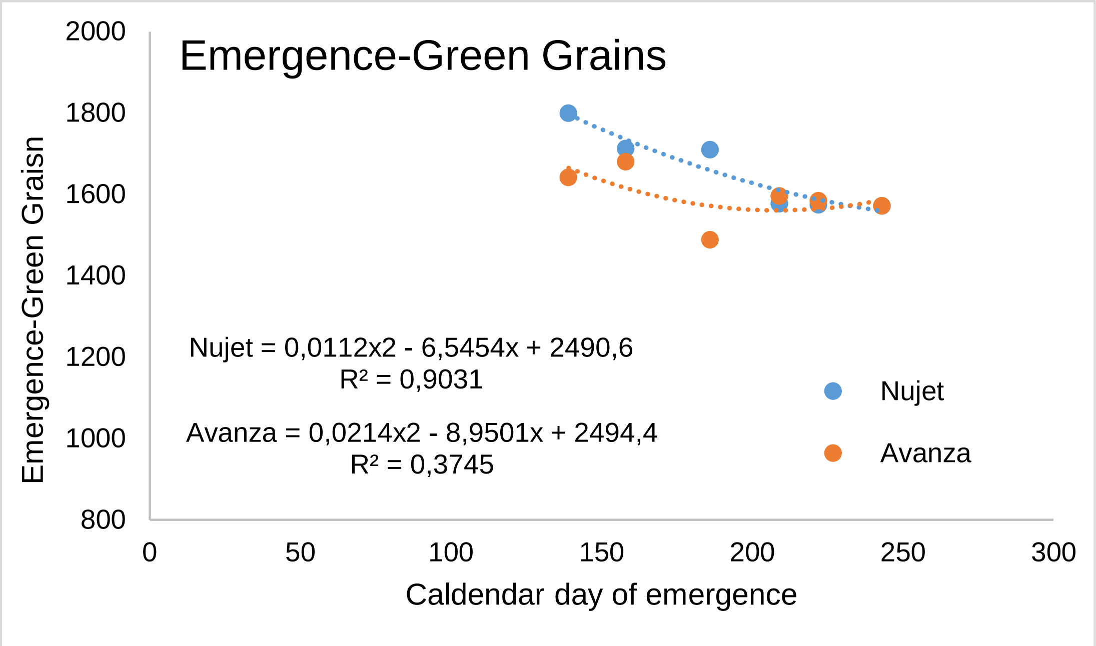




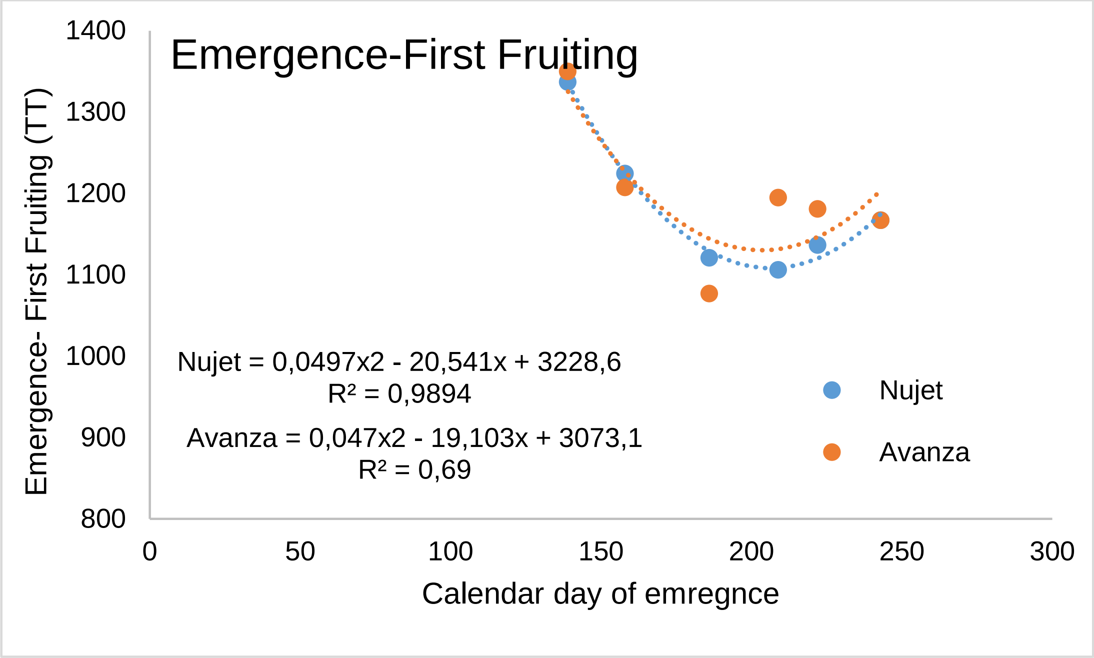
Expected for photoperiod long-day response

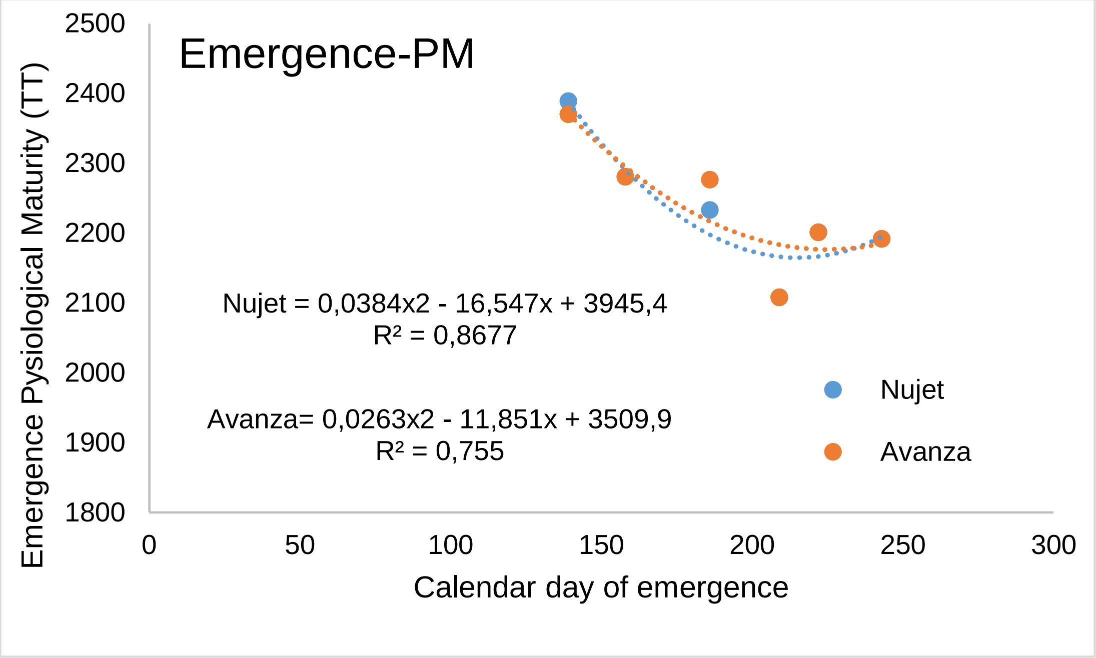
Algorithms for the Cronocarinata model





Expected for photoperiod long-day response



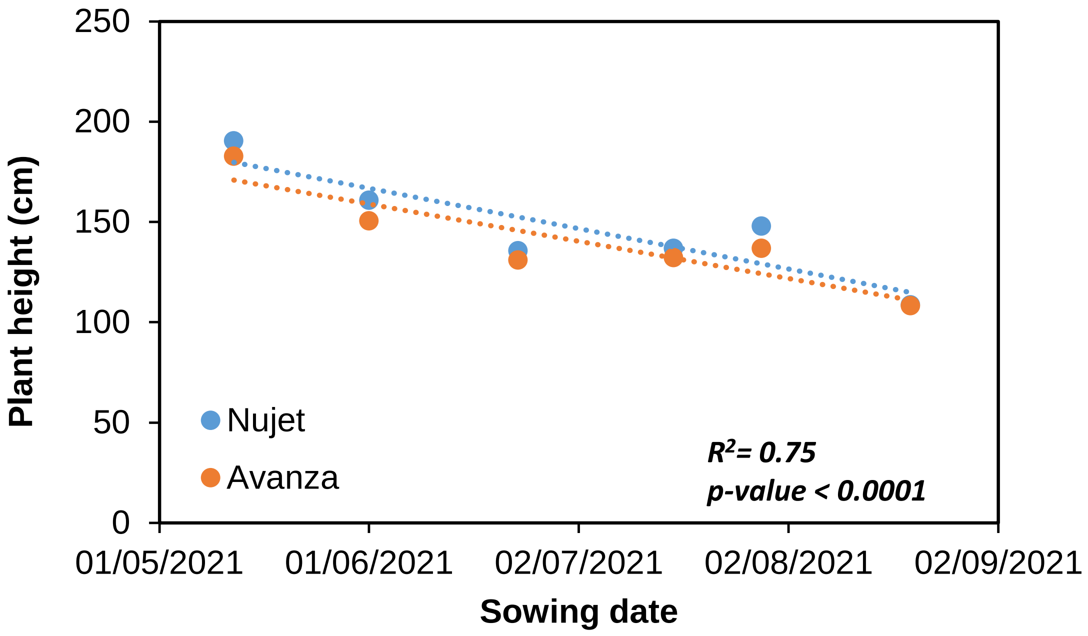


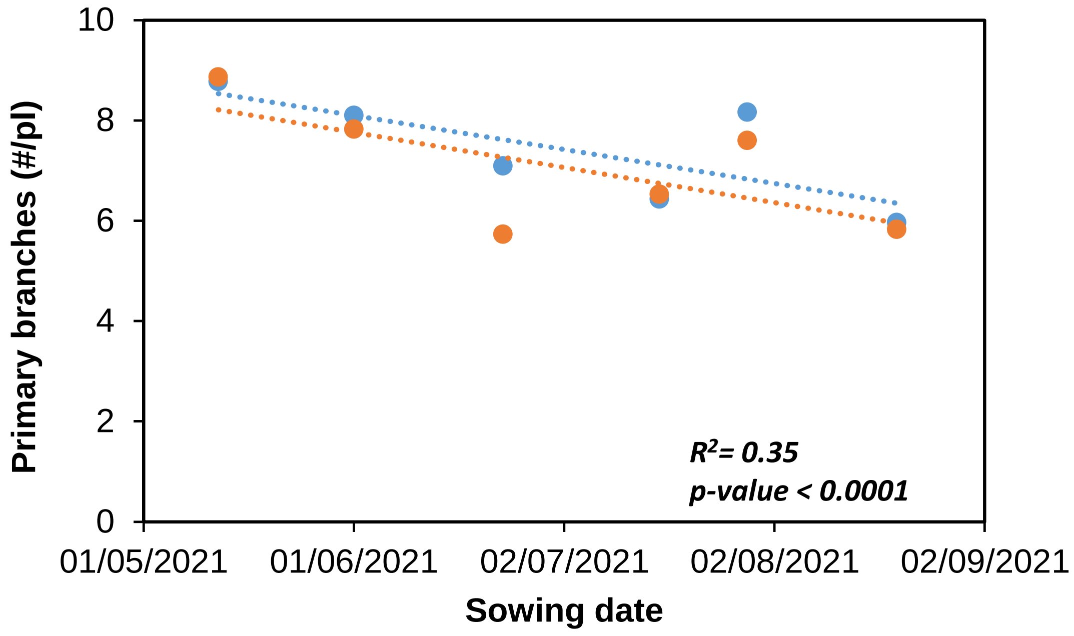
Scheme of how the CRONOCARINATA model will look like

IMPORTANT: At the moment we are running the algorithms by R program using an historical series of meteorological data during the last 35 year in more than 200 locations of the Argentina. The program will be ready in the next month. Then, validation with independent data (from Nuseed and Uruguay) will be made.

Canopy structure and productivity across sowing dates

At crop maturity of every sowing date, 1 m-row was hand-harvested for each row in the plot, biomass was dried and weighed, seeds were hand-threshed, and thousand seed weight was measured. Five plants from each row was measured for canopy structure.

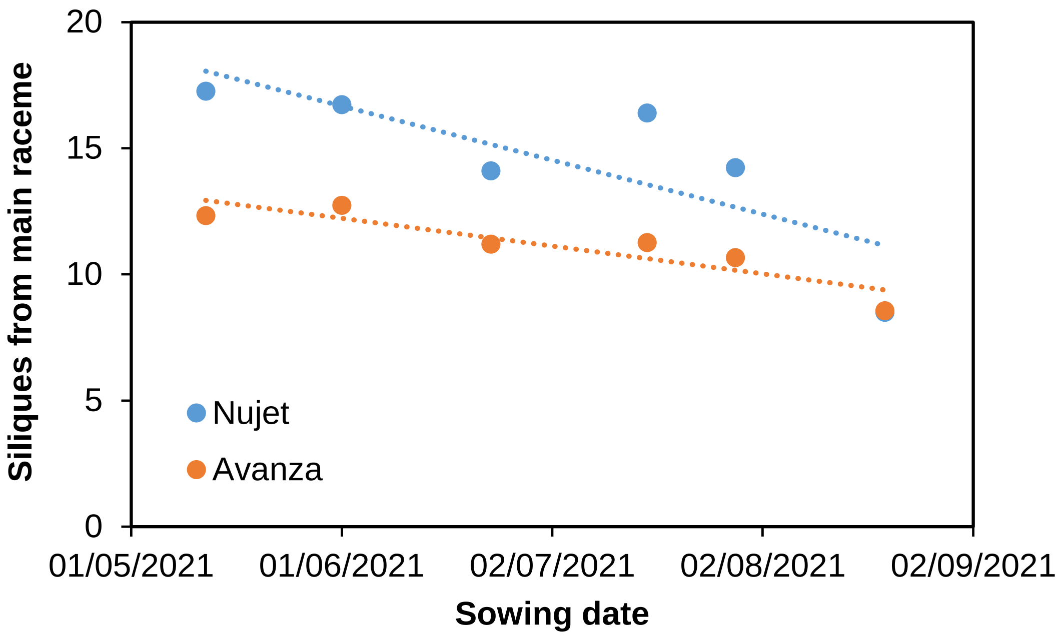


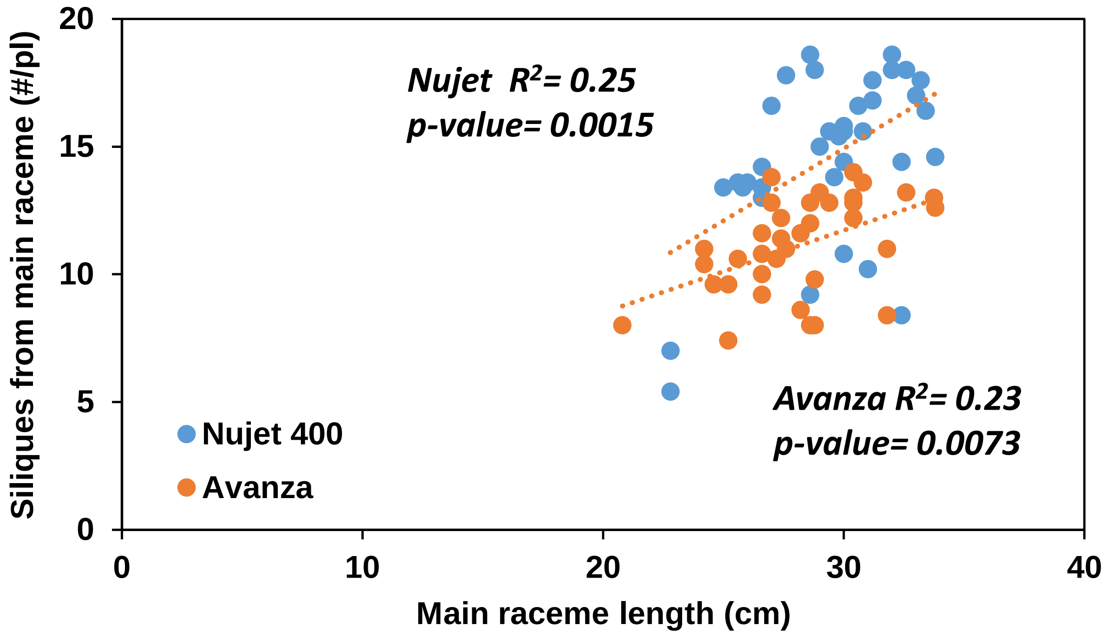


-Very tall and branched plants (more than canola)

-Plant height and branching are reduced by delaying sowing date

Carinata structure across sowing dates



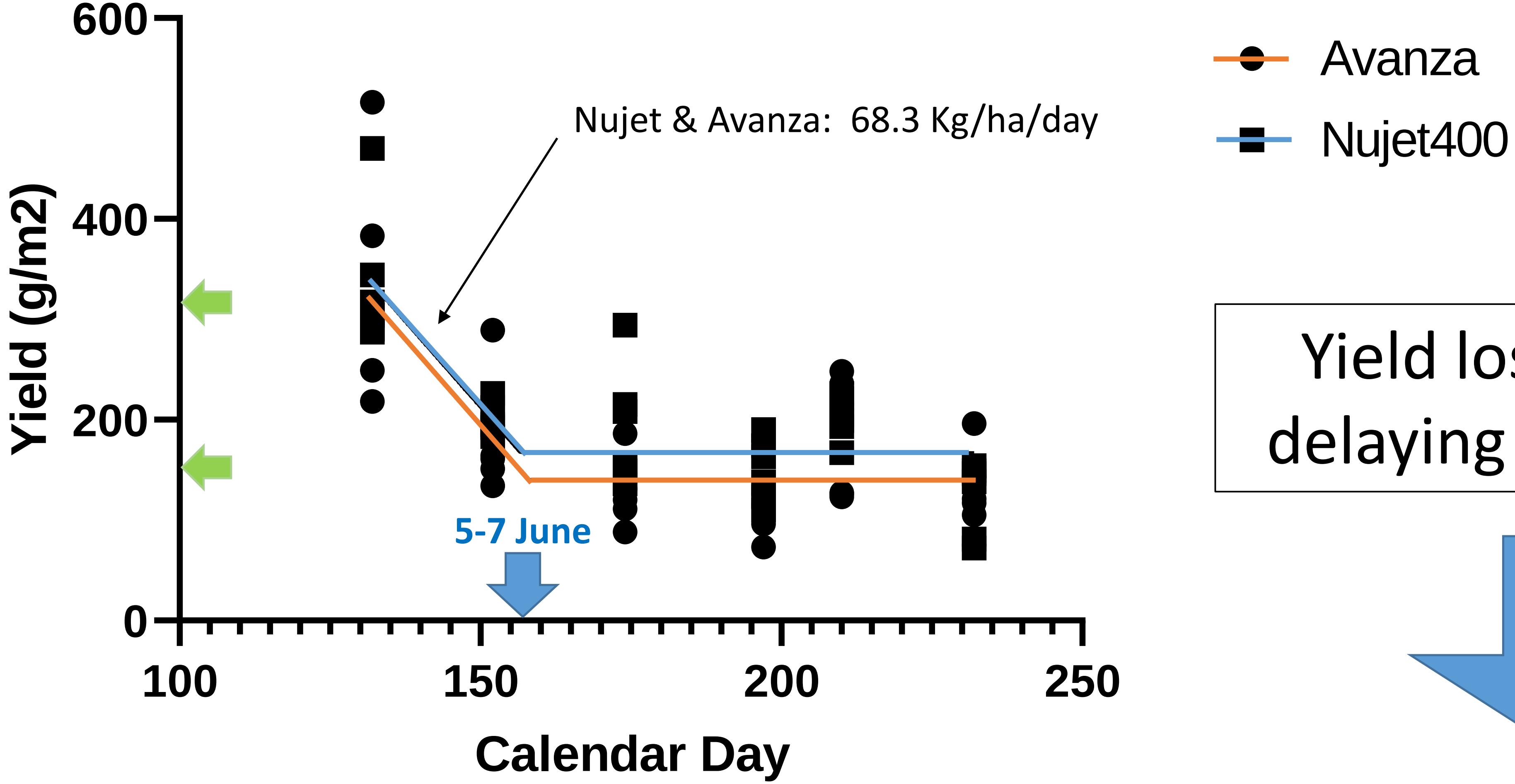


-More siliques from the main raceme in Nujet 400 than Avanza 641, across sowing dates

-Positive relationship between the number of siliques and the main raceme length

Yield losses by changes in sowing dates

Seed yields in the range cited from the literature (Mazzilli 2020; Seepaul et al 2021)



Yield losses per day of delaying in sowing dates

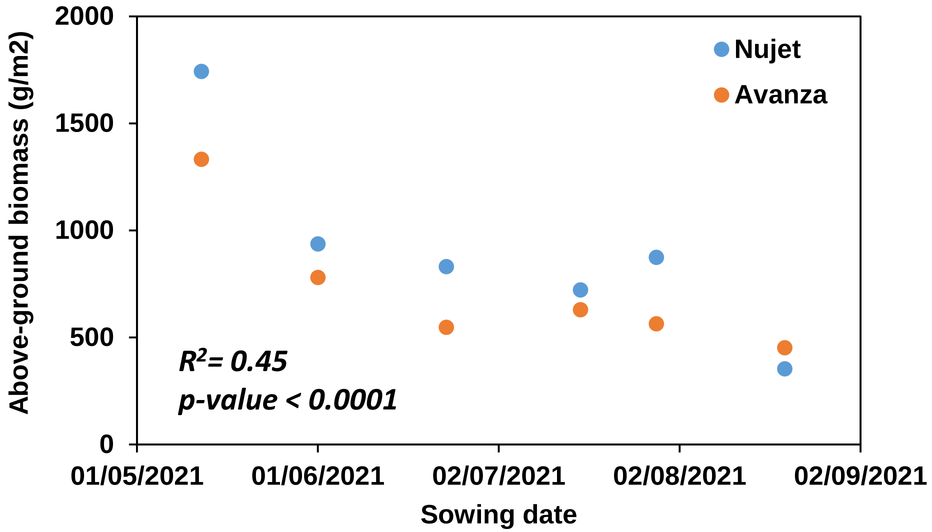
-Average grain yield from 3500 to 1500 kg/ha depending on sowing date

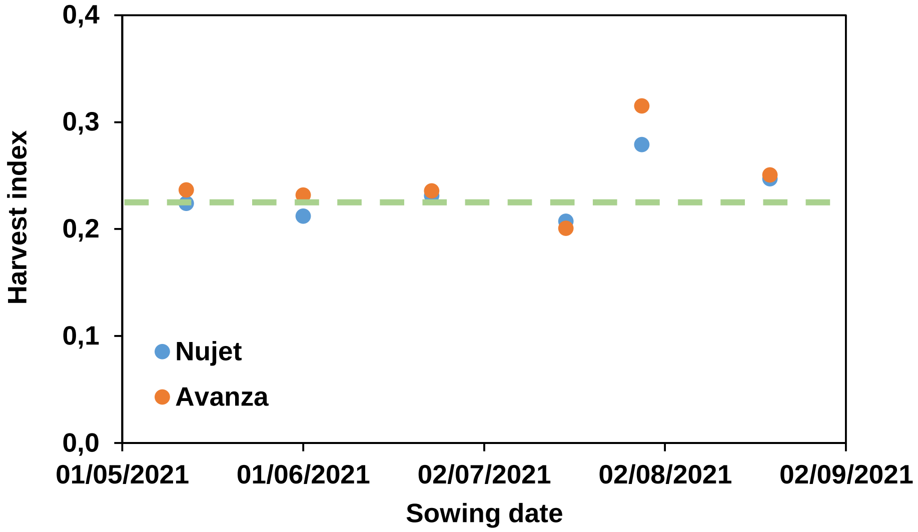
-Slightly advantage for Nujet 400 (but high data variability among replicates)

Bilineal 2 Parameters ± standard errors

Best-fit values	Avanza	Nujet400
Intercept	1221±258	1237±203
Slope	-6.833±1,8	-6.833±1,4
Inflexion Point	158±5	156±4

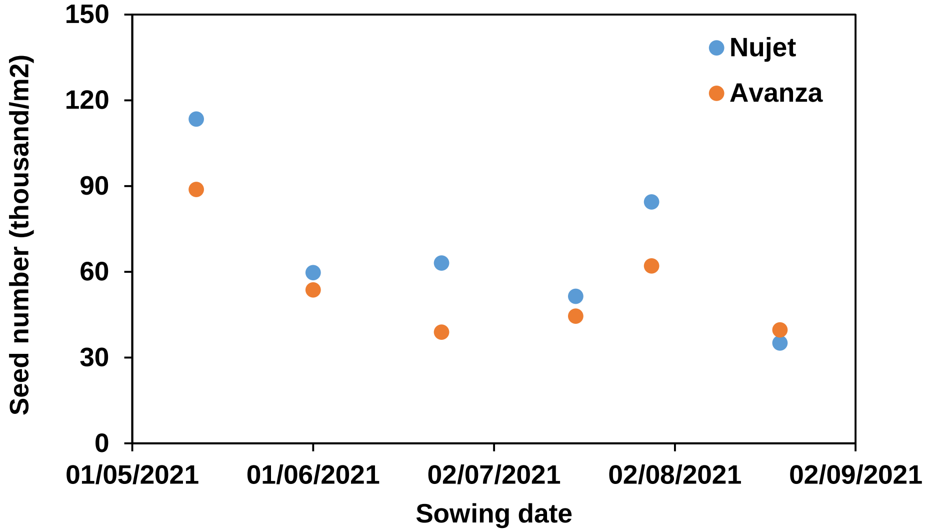
Seed yield components varied with delayed sowing date

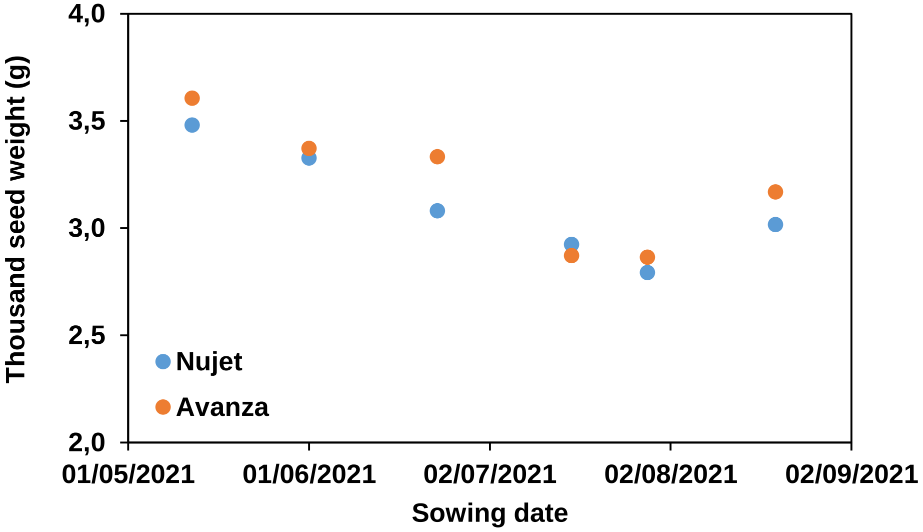




-Above-ground biomass was reduced by delayed sowing date

-By contrast, harvest index was mainly low and unchanging (0.2-0.3)

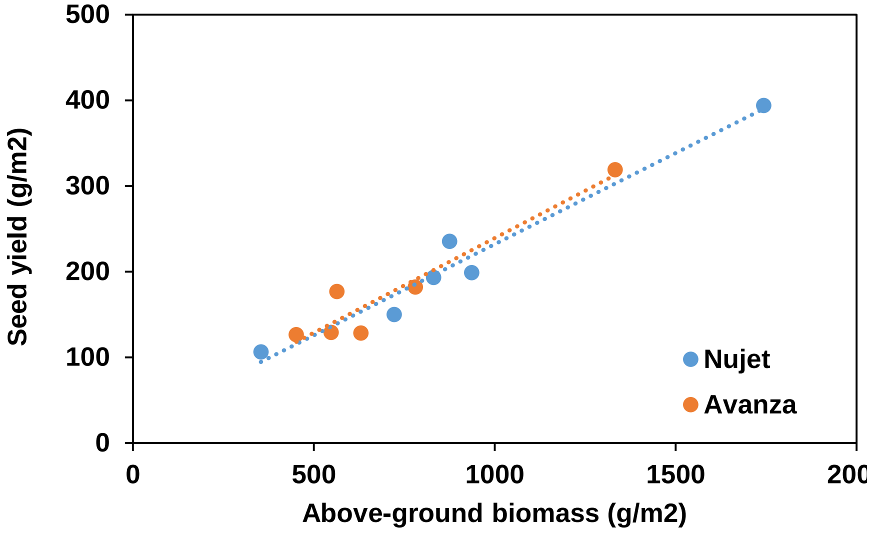


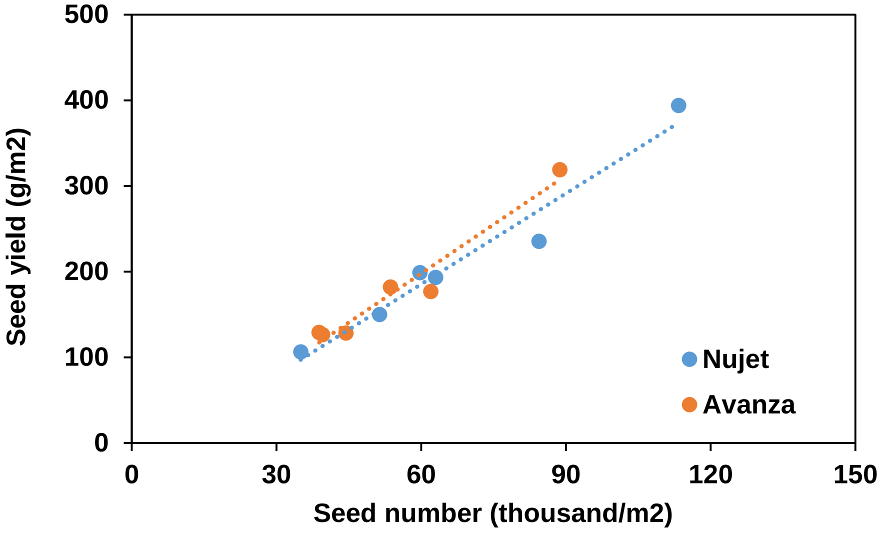


-Both, seed number and seed weight were reduced by delayed sowing (without compensatory effects)

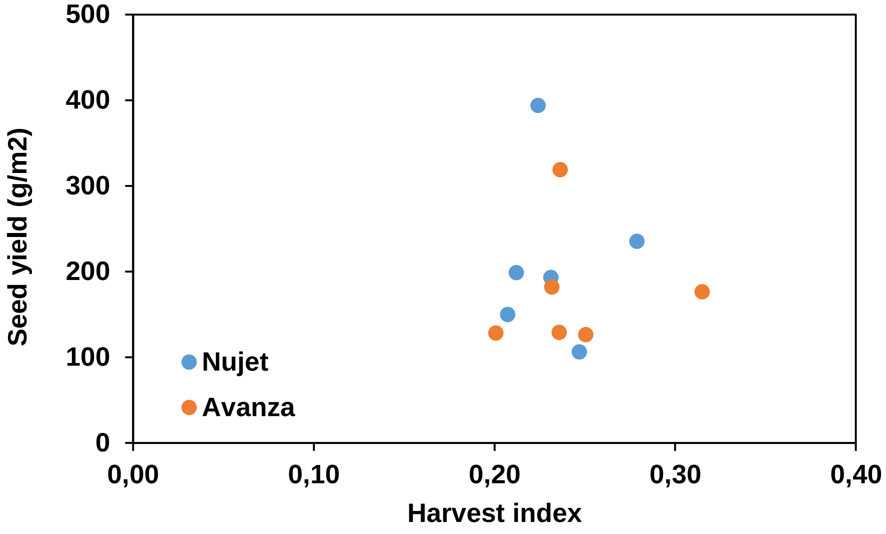
-Nujet has higher seed number but lower seed weight

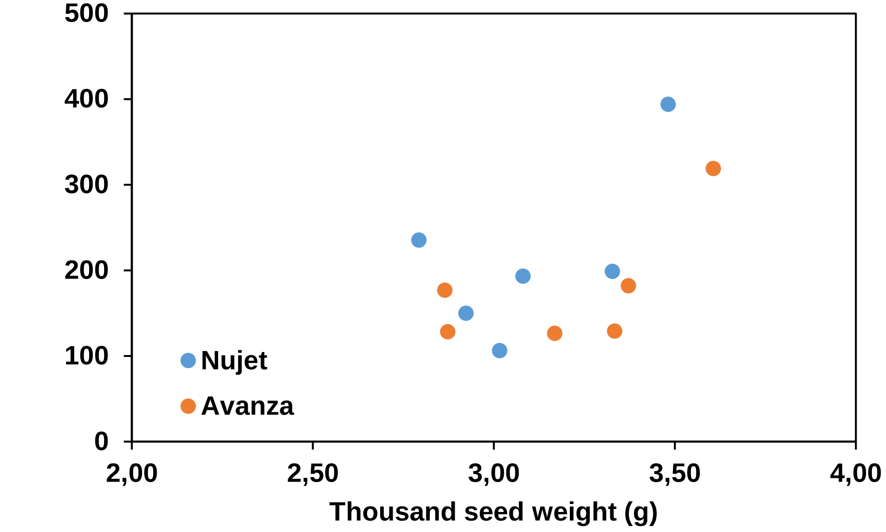
Seed yield components





-As expected, seed yield across sowing date is strongly associated with above-ground biomass, and seed number per area unit.





-No relationship were observed between seed yield and harvest index or seed weight

Final Conclusions 2021
and Plan 2022

Conclusions Section A: Biomass

- <u>Similar crop phenology</u> in both genotypes (for sowing in late June)
- Quick soil coverage (from 30 to 60 DAE) in August with **LAI= 2.5-3**
- Light capture efficiency (>90%) by early September at visible floral bud
- Similar biomass allocation in both genotypes with **2/3 of total biomass accumulated during post-flowering**
- Aerial biomass at harvest (9-10 ton/ha) is mainly allocated in branches (45%) and stem (35%), with only 15% in the main raceme
- At flowering ≈ **1 ton/ha of dry biomass in roots** (20-30% of aerial biomass at flowering)
- After maturity ≈ **1 ton/ha in roots (10-12% of aerial biomass at harvest**) useful to calculating C sequestration
- **Shoot/root ratio** at harvest (**8-10**) in the range of *B. carinata* in Uruguay (7.5-11)

- Reproductive biomass moisture dynamics similar to canola pods (70% pod moisture after flowering and **fast drying from 50-53 days after flowering**)
- **High radiation-use efficiency (RUE) post-flowering** (0.8-0.9 g/MJ solar radiation)
- RUE for corrected biomass: 1.2 g glucose/MJ solar radiation
- Water use efficiency (WUE): **7.9 and 7.3 kg seed/ha/mm (ETc)** for Nujet and Avanza
- Seed yield (2300-2200 kg/ha) tended to be higher in Nujet respect to Avanza
- **Heavier grains in Avanza** than Nujet
- <u>Valuable seed composition</u> for Avanza and Nujet (49 and 45% oil, 20% protein)
- Both genotypes showed similar **oil yield (1070 kg oil/ha**) and **protein yield (450 kg protein/ha**)
- Particulated organic matter in soil 30 days after harvest (0.26-0.33 %)

Conclusions Section B: Phenology by sowing dates

- Both genotypes had very similar crop phenology
- **Crop cycle was shortened as sowing dates was delayed** (from mid May to late August) from 180 to 125 days from sowing (2100 to 1900 °Cd from emergence)
- First flowering was from **August 30 to October 31** across sowing days, without risk of frost in Buenos Aires
- On average, **flowering is delayed one week for every 10 days of delay** in sowing
- Long-day photoperiodic response with higher sensibility (-500°Cd /h) and similar precocity to short-cycle bread wheat
- **Seed yield reduction** (68 kg/ha per day of delay) up to early June

- Above-ground biomass, plant height and branching are reduced as sowing is delayed
- HI remains low (0.2-0.3) across sowing dates
- Seed number and seed weight are both reduced by delayed sowing (without compensatory effects)
- **Heavier grains in Avanza** than Nujet
- <u>More siliques from the main raceme in Nujet</u> than Avanza
- As expected, above-ground biomass and seed number better explain seed yield
- Algorithms for Cronocarinata model ready

Plan 2022

- Repeat experiments with broader sowing dates (from early March to late August)
  Run the phenological model CRONOCARINATA for 200 locations in Argentina

- Add more root sampling after flowering and more soil measurements after harvest
  Water inputs (rains and drip irrigation better measured) and confirm the Kc evolution during post-flowering
  Build a model of carinata crop maturity based on raceme moisture dynamics
  Use experimental data to calculate C sequestrion

- Validation and re calibration of the phenological model CRONOCARINATA with independent data (2022 experiments + Uruguay + Nuseed data)

- Publish results (carinata meetings and scientific papers)

Thanks for inspiring and supporting this work

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