Technical agreement NUSEED-FAUBA

Results from 2021 to 2022 and Experiments during 2023

21 July 2023

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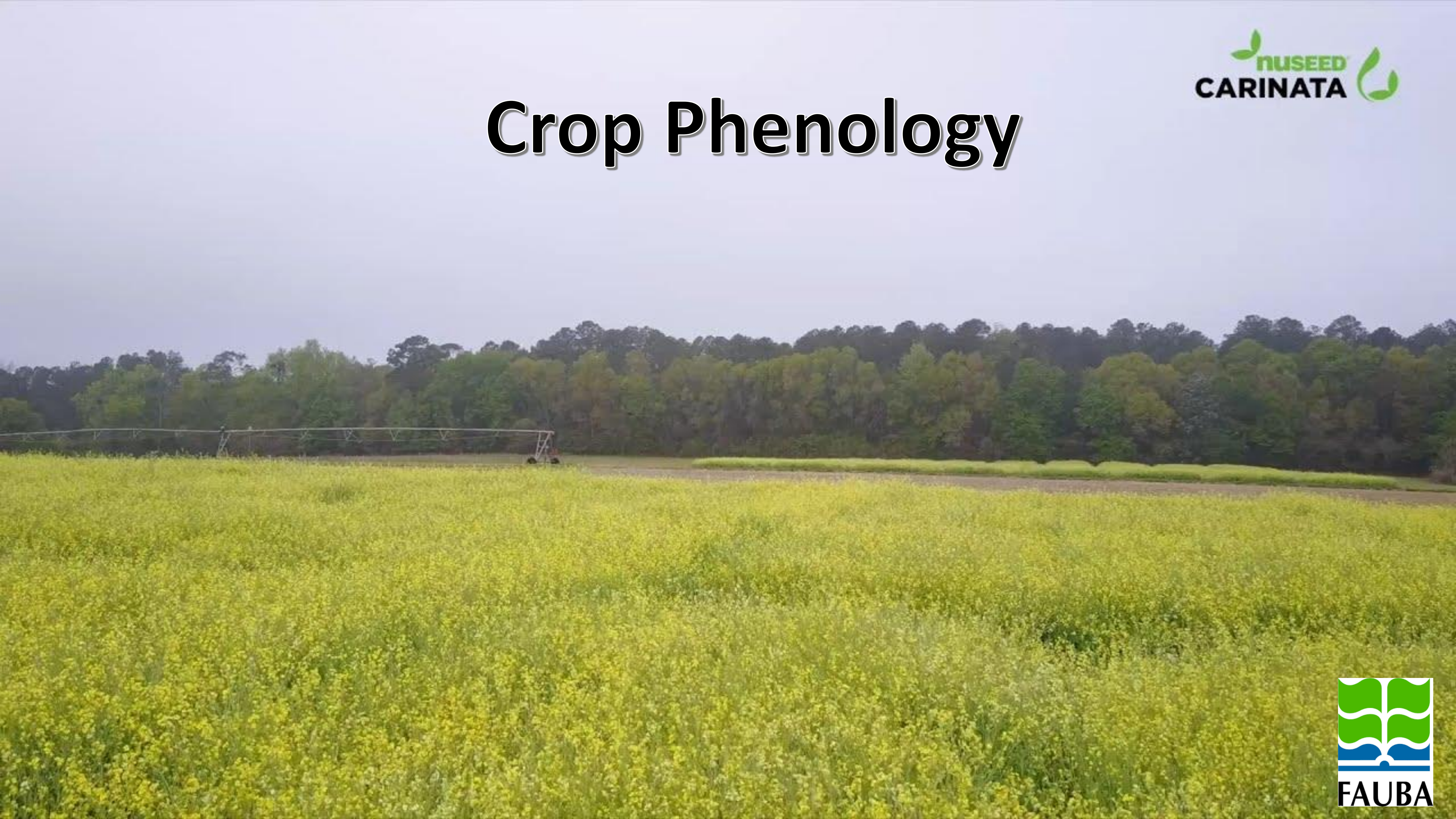
Crop Phenology



CHRONOCARINATA: A simple model for predicting phenology

2021

Genotypes	Nujet 400; Avanza 641

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

2022

Sowing	Dates	Genotypes
SD1	3/3/22	Nujet 400; Avanza 641
SD2	17/3/22	Nujet 400; Avanza 641
SD3	1/4/22	Nujet 400; Avanza 641; E63; E 68; E87
SD4	13/4/22	Nujet 400; Avanza 641; E63; E 68; E87
SD5	30/4/22	Nujet 400; Avanza 641; E63; E 68; E87
SD6	11/5/22	Nujet 400; Avanza 641; E63; E 68; E87
SD7	3/6/22	Nujet 400; Avanza 641; E63; E 68; E87; E93
SD8	23/6/22	Nujet 400; Avanza 641; E63; E 68; E87; E93
SD9	*16/7/22*	Nujet 400; Avanza 641; E63; E 68; E87; E93
SD10	*29/7/22*	Nujet 400; Avanza 641; E63; E 68; E87; E93
SD11	*20/8/22*	Nujet 400; Avanza 641; E63; E 68; E87; E93

PHENOLOGY: Data collected during 2022 to build the CRONOCARINATA model

During 2021 and 2022 growing seasons 6 and 11 sowing dates were carried out at the experimental field of the School of Agriculture University of buenos Aires from early of March to late in August. Sowing dates are detailed as follow: 3 March, 17 March, 1 April, 13 April, 30 April, 11 May, 3 June, 23 June, 16 July, 30 July, and 19 August.

In 2022, the genotypes included in the analysis were: NUJET 400, AVANZA, E63, E68, E87 and E93 (NUJET 350). The genotypes E63, E68 and E87 were included from the 3rd sowing date (1 April) onward and the genotype E93 participated from the 7th sowing (3 June) onward due to in all cases the seed arrived later to the University.

In all cases the density was 100 plants/m^2 and experiments were irrigated and fertilized for avoiding abiotic stress. Fungicides and insecticides were applied to prevent insect and diseases.

Phenological stages recorded were: Sowing, emergence, 4 leaves appeared (Rosset stage), floral visible bud, first flowering, first fruiting, green grains, colored grains, maturity and harvest. In all cases the stage was recorded when 50% of the plants reached each particular stage.

NOTE: At this time all data were collected, and we are waiting for the UTI (Informatic Technology Unit) of FAUBA to build the CRONOCARINATA model

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

Photo: June 3, 2022

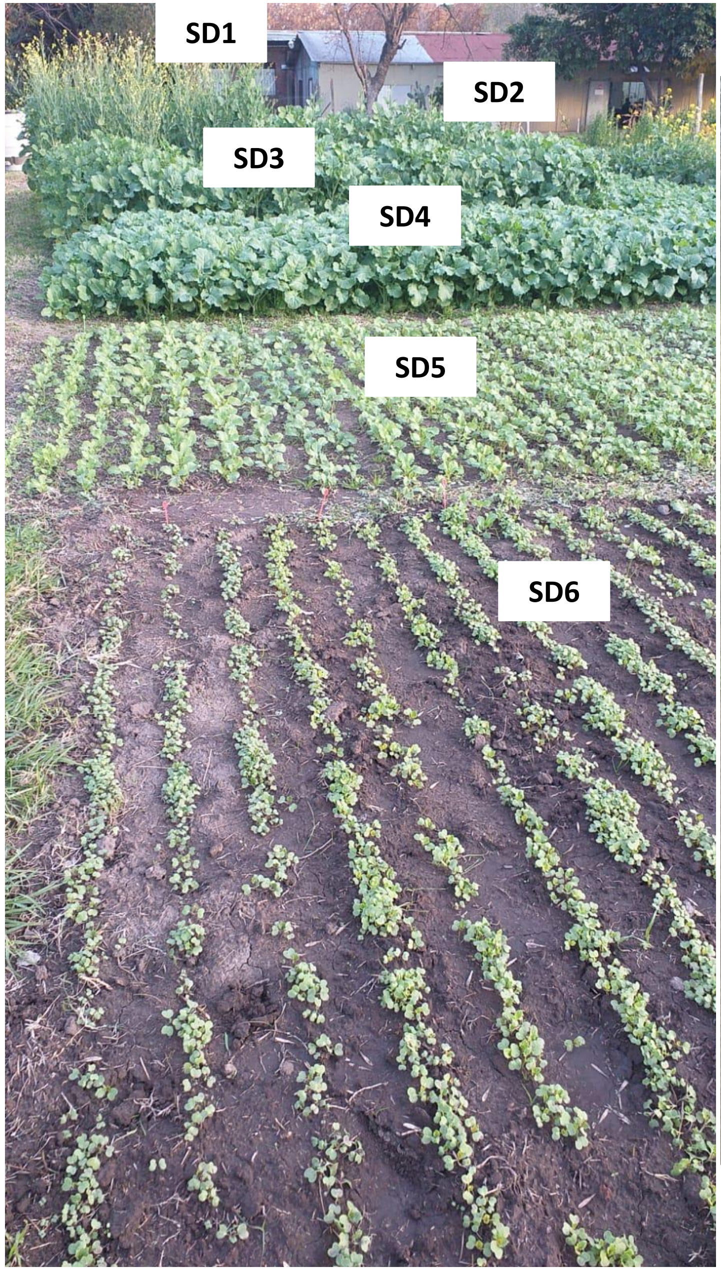
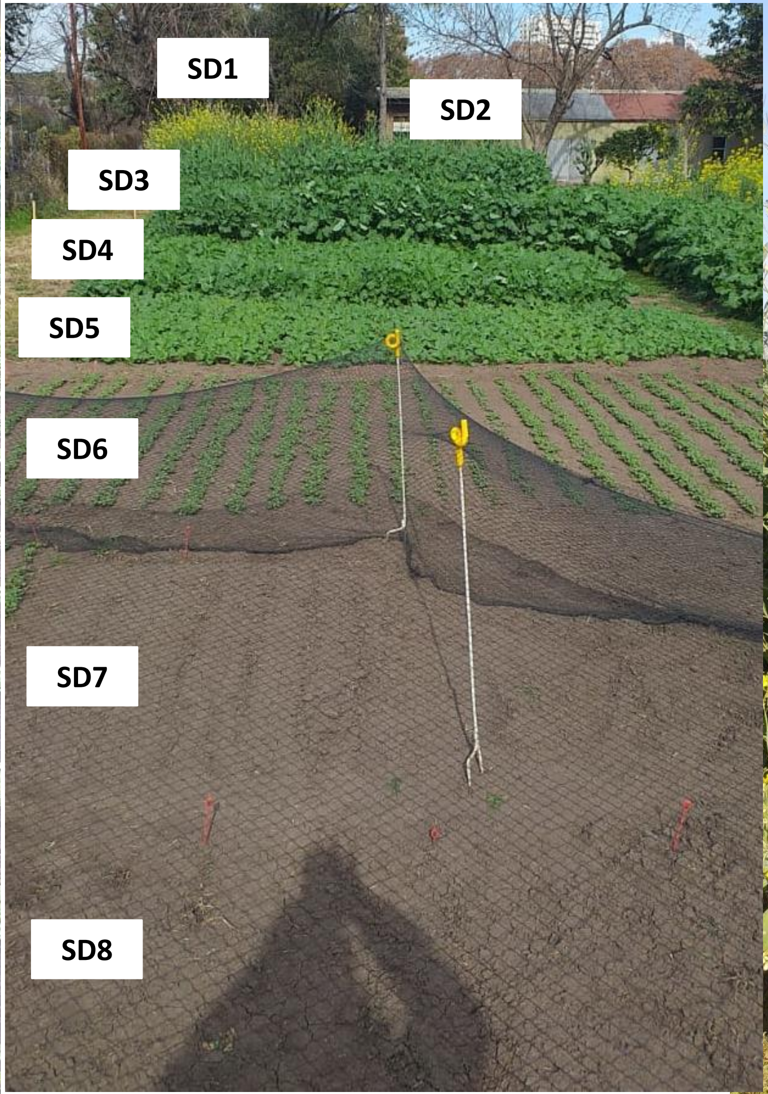
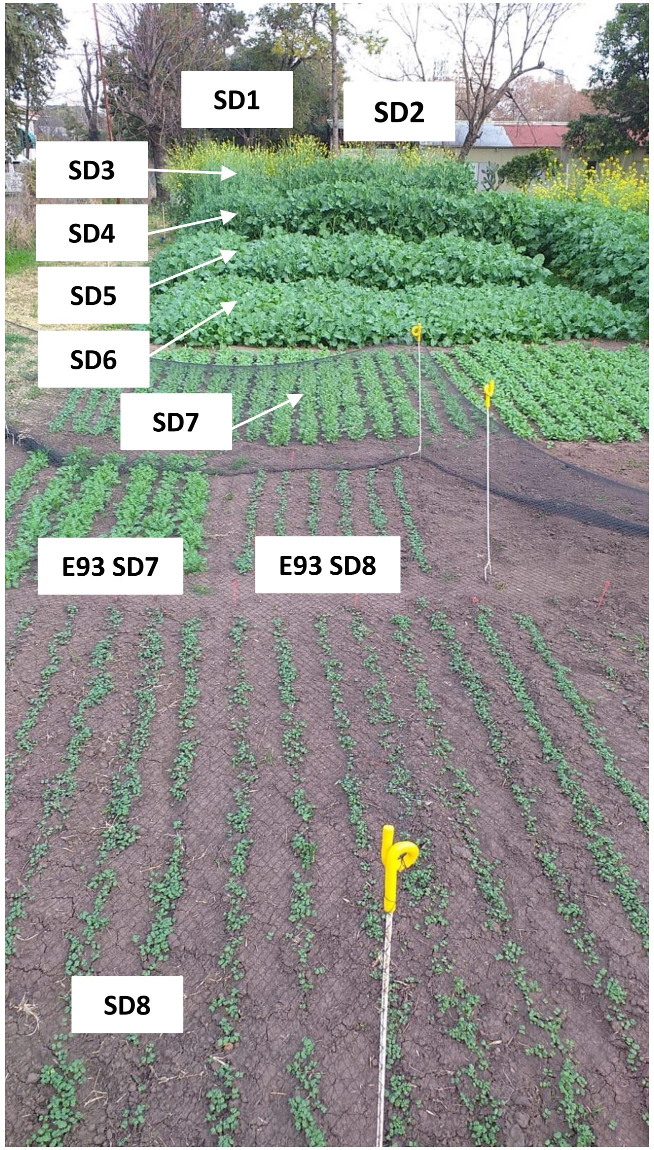


Photo: June 29, 2022

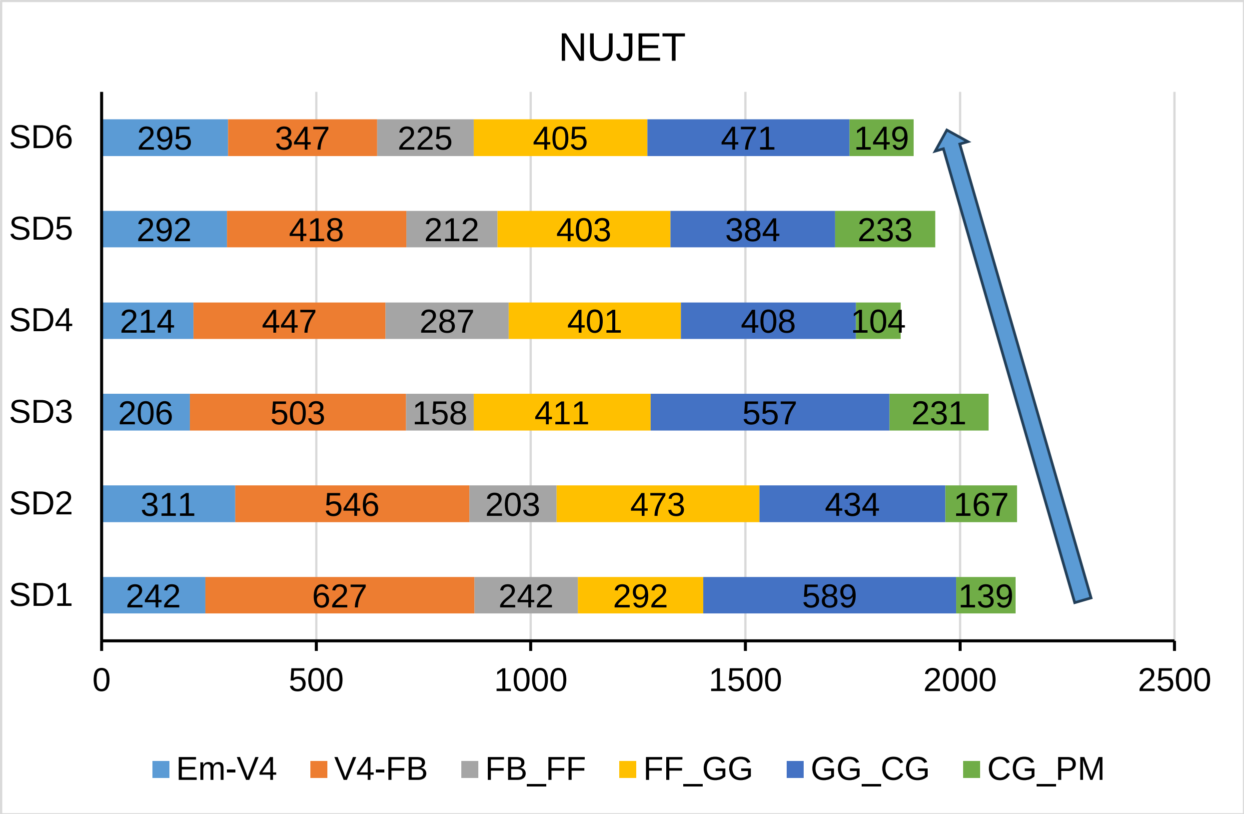


July 12, 2022

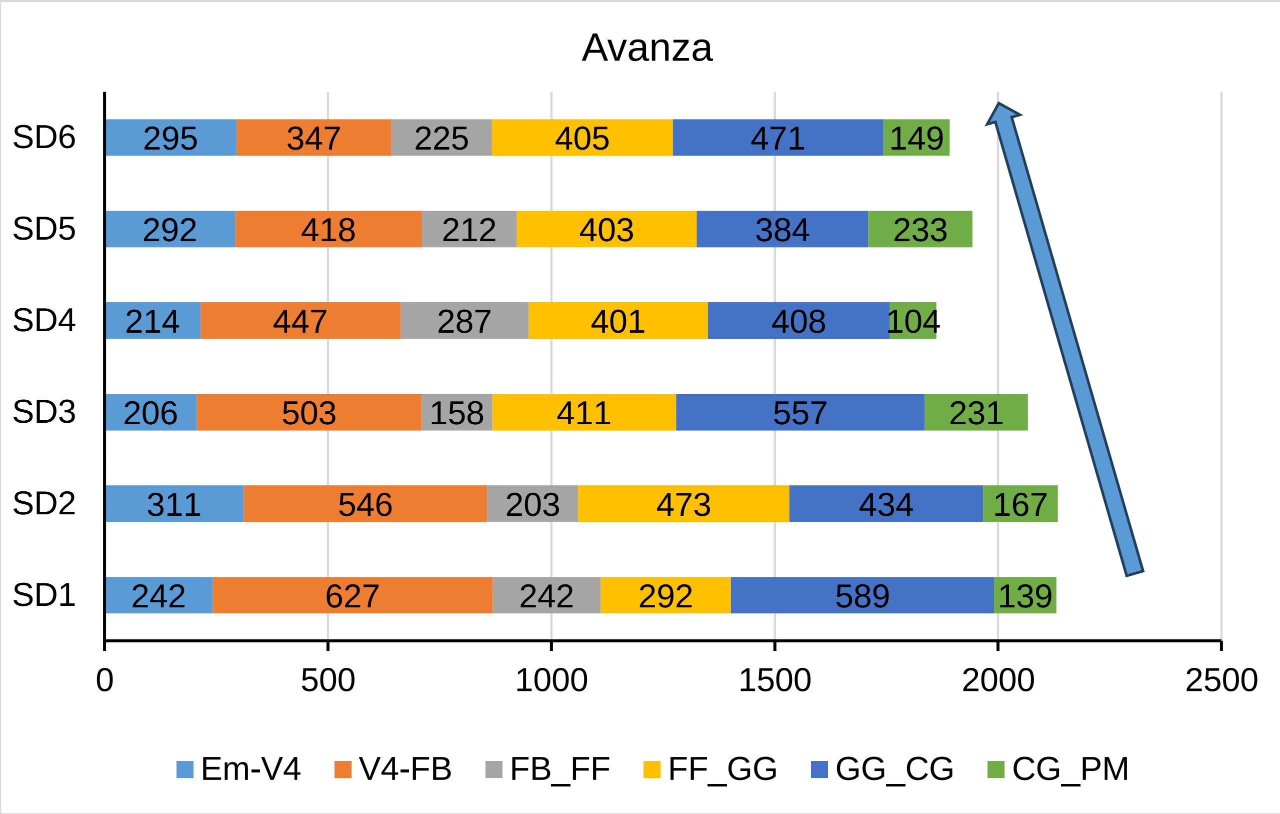
Very tall plants in early SD. Stakes and ties were placed in the plots to prevent lodging



Phenology and sowing dates



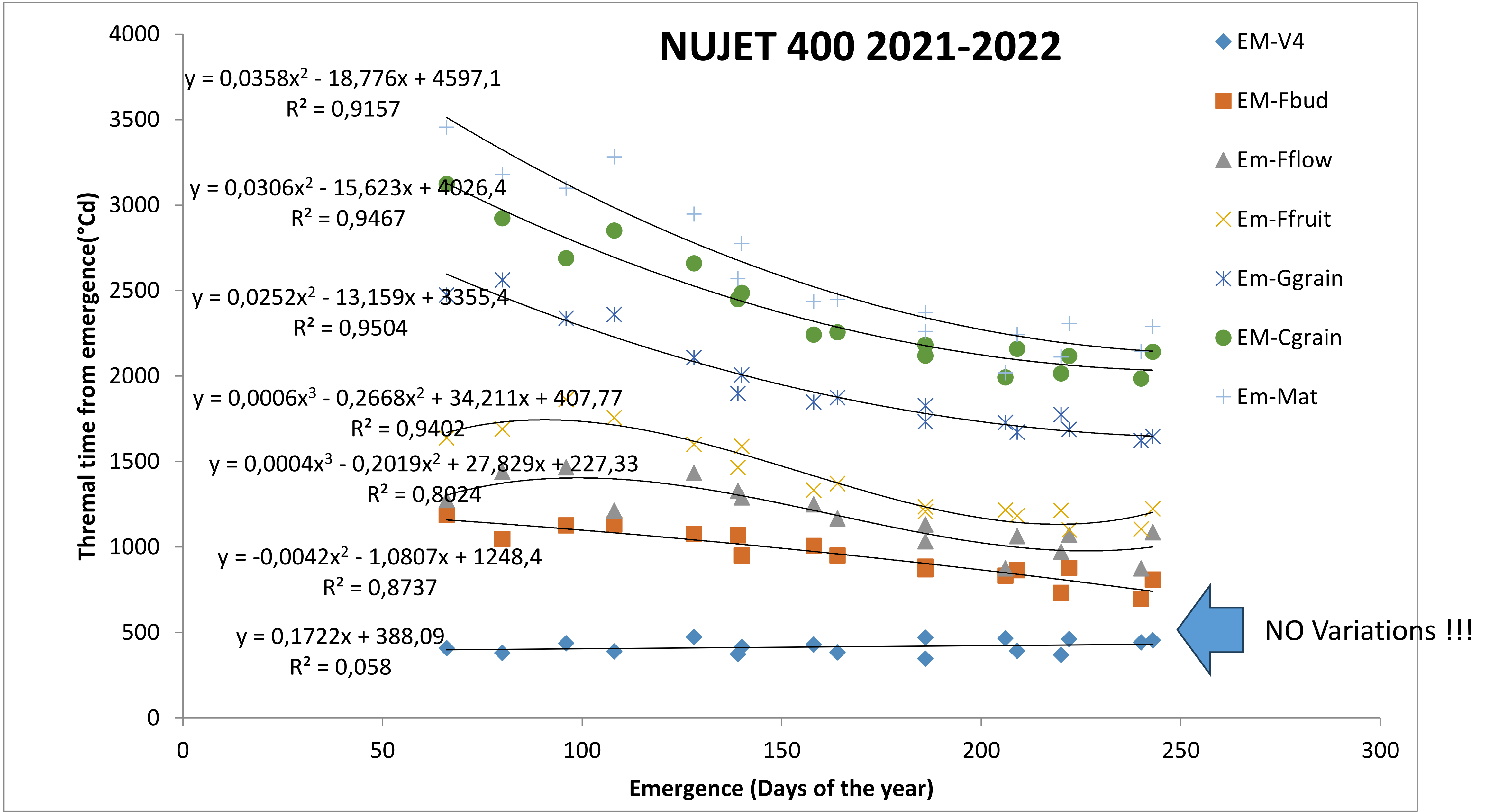
Thermal Time (°Cd)



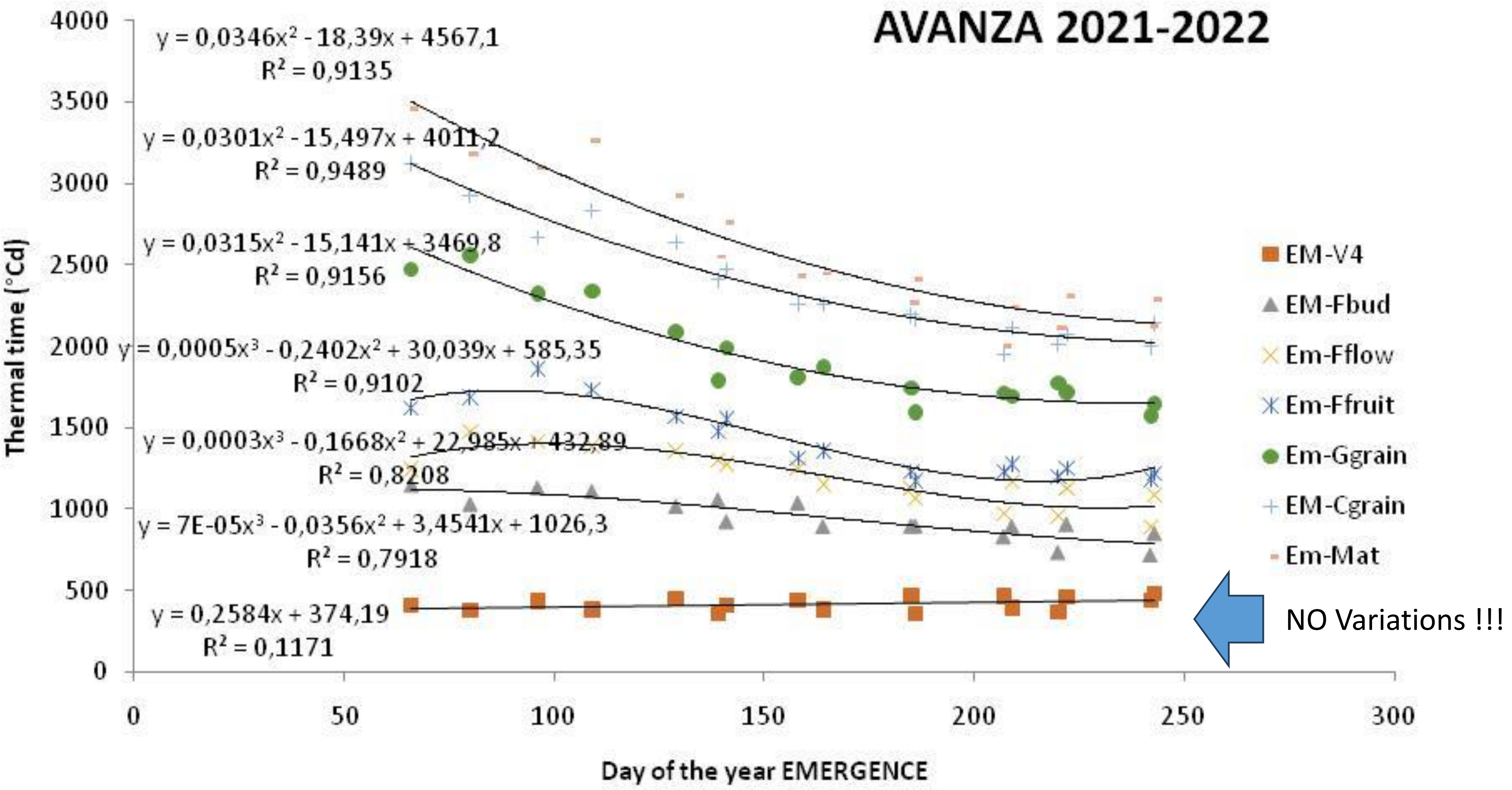
Thermal Time (°Cd)

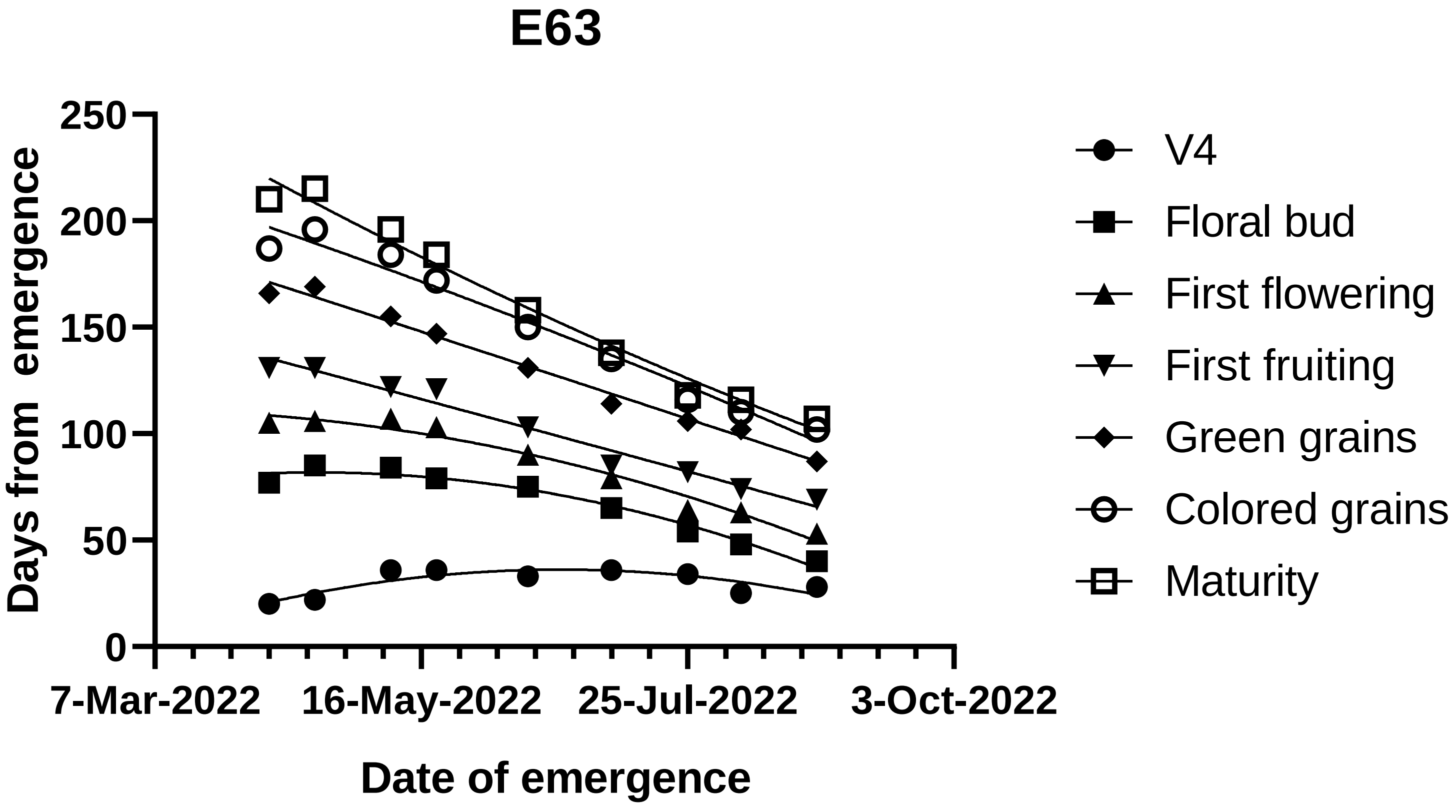
The duration of the cycle was shortened as sowing dates was delayed. Sowing dates were from: Middle may (12 May) to late August (20 August)

Phenological adjustments for NUJET 400 for different phases during 2021-2022



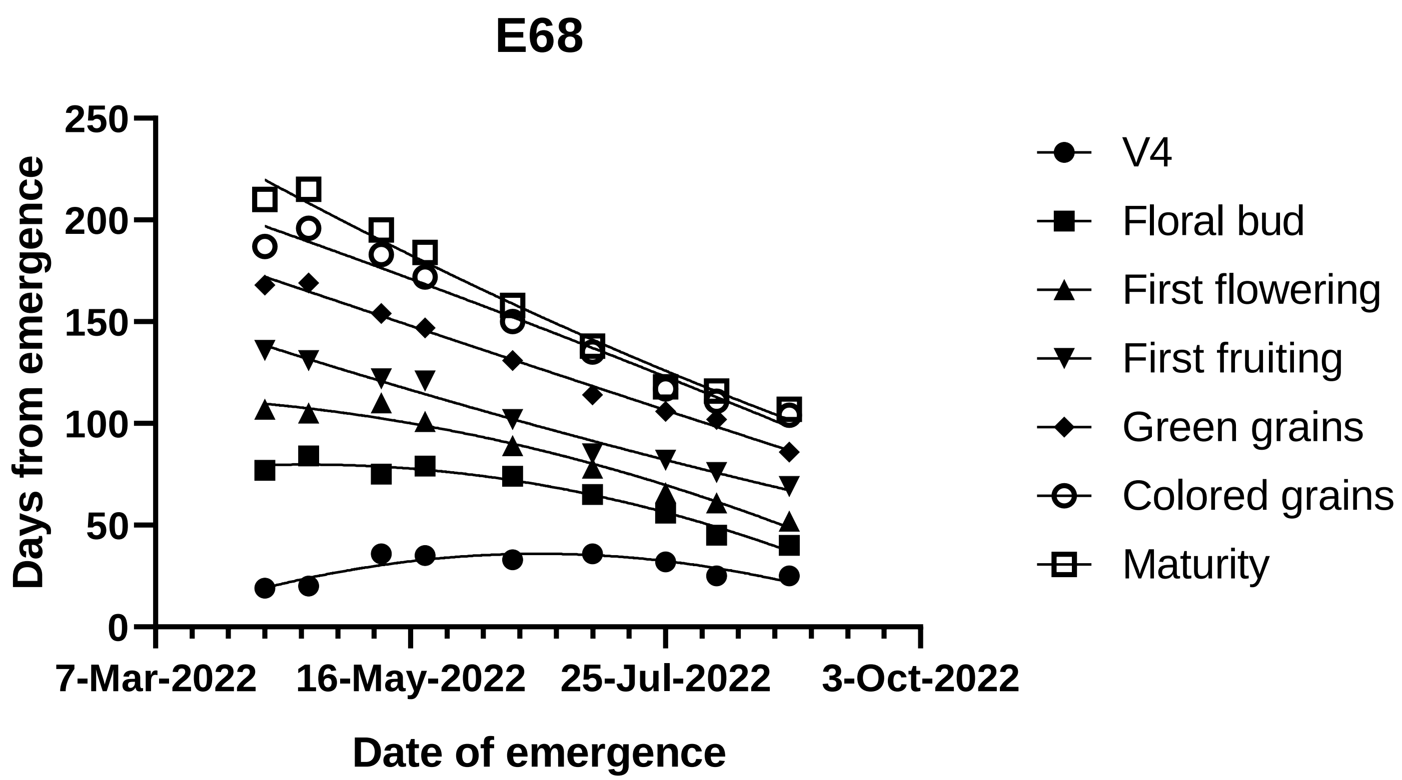
Phenological adjustments for AVANZA for different phases during 2021-2022





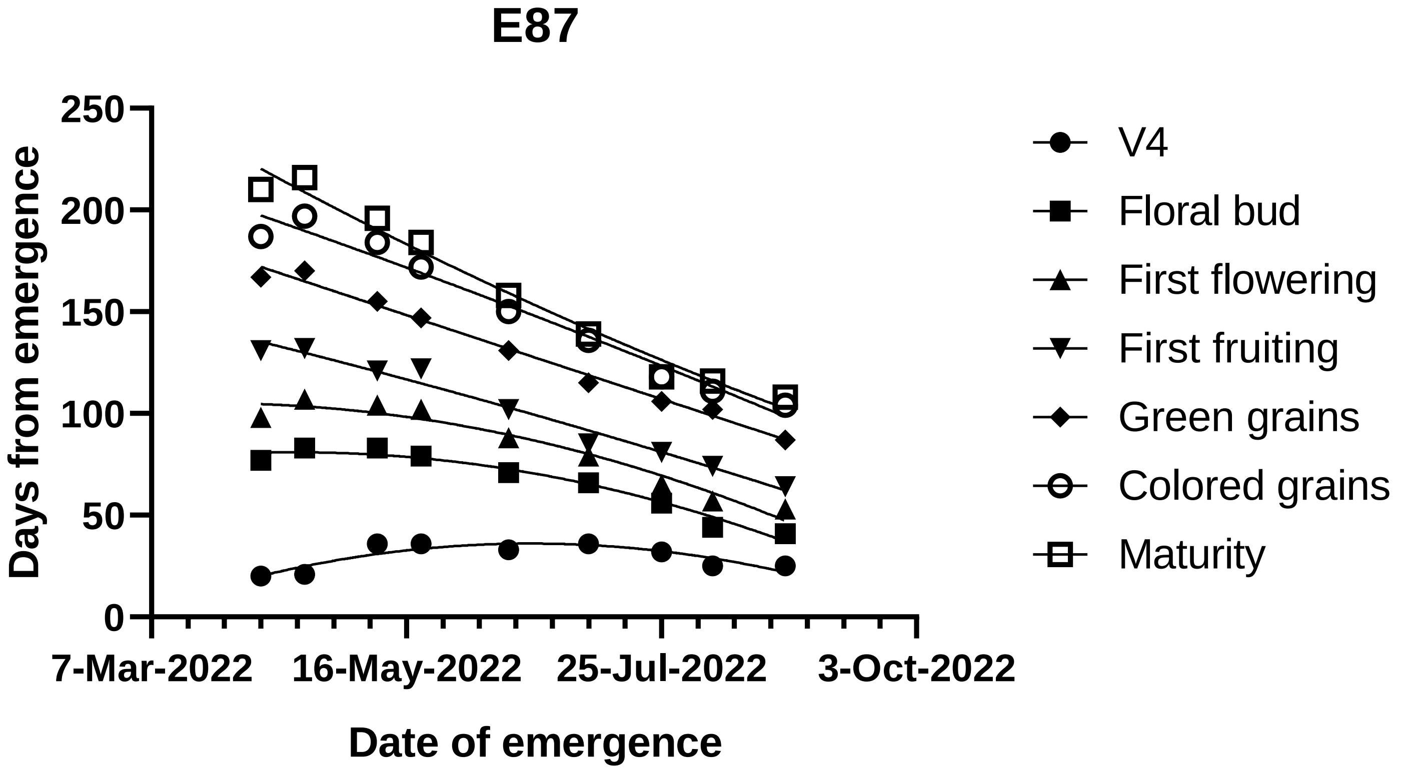
E63: This genotype showed similar trend than the other commercial materials (NUJET and AVANZA). However, the differences between phases in the earliest sowings, especially from floral bud to the rest of the phases were lower than the other previous genotypes.

	V4	Floral bud	First flowering	First fruiting	Green grains	Colored grains	Maturity
Second order polynomial (quadratic)							
Best-fit values							
B0	6,390	77,18	111,0	149,8	188,7	214,9	249,6
B1	3,906	1,535	-0,1638	-3,327	-4,061	-4,063	-7,140
B2	-0,1280	-0,1269	-0,09300	-0,002181	-0,001086	-0,02843	0,04787
95% CI (profile likelihood)							
B0	-9,235 to 22,01	64,31 to 90,05	94,00 to 128,0	131,3 to 168,3	173,3 to 204,0	187,6 to 242,3	221,9 to 277,4
B1	1,395 to 6,416	-0,5329 to 3,603	-2,894 to 2,566	-6,300 to -0,3543	-6,529 to -1,592	-8,452 to 0,3258	-11,60 to -2,685
B2	-0,213 to -0,0425	-0,197 to -0,0564	-0,186 to -3,853e-006	-0,1035 to 0,09909	-0,0852 to 0,08300	-0,1779 to 0,1211	-0,1039 to 0,199
Goodness of Fit							
Degrees of Freedom	6	6	6	6	6	6	6
R squared	0,7095	0,9705	0,9694	0,9735	0,9873	0,9722	0,9793
Sum of Squares	94,70	64,27	112,0	132,8	91,56	289,5	298,3
Sy.x	3,973	3,273	4,321	4,705	3,906	6,946	7,051



E68: This genotype showed similar trend than the other commercial materials (NUJET and AVANZA). However, the differences between phases in the earliest sowings, especially from floral bud to the rest of the phases were lower than the other previous genotypes.

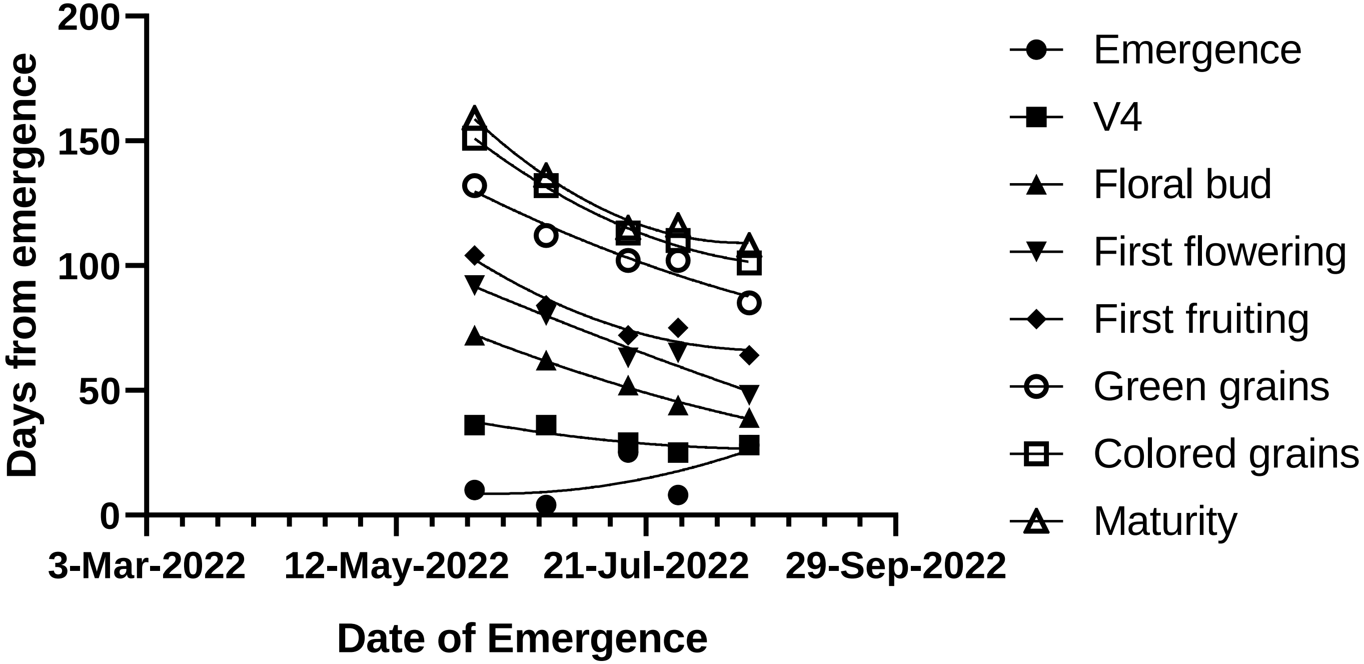
	V4	Floral bud	First flowering	First fruiting	Green grains	Colored grains	Maturity
Second order polynomial (quadratic)							
Best-fit values							
B0	3,064	75,68	113,1	155,8	190,3	215,6	249,6
B1	4,373	1,402	-0,4213	-4,177	-4,266	-4,268	-7,164
B2	-0,1454	-0,1186	-0,08716	0,02452	0,003970	-0,01804	0,04913
95% CI (profile likelihood)							
B0	-11,73 to 17,86	62,28 to 89,08	96,62 to 129,5	140,1 to 171,6	176,9 to 203,8	188,6 to 242,6	222,3 to 276,8
B1	1,996 to 6,750	-0,7500 to 3,555	-3,065 to 2,223	-6,702 to -1,651	-6,426 to -2,106	-8,600 to 0,06398	-11,54 to -2,790
B2	-0,2263 to -0,0644	-0,1919 to -0,04529	-0,1772 to 0,00290	-0,06151 to 0,1105	-0,0696 to 0,07755	-0,1656 to 0,1295	-0,0998 to 0,1981
Goodness of Fit							
Degrees of Freedom	6	6	6	6	6	6	6
R squared	0,7718	0,9648	0,9727	0,9816	0,9905	0,9718	0,9799
Sum of Squares	84,90	69,62	105,1	95,84	70,11	282,0	287,4
Sy.x	3,762	3,406	4,185	3,997	3,418	6,856	6,921



E87: This genotype showed similar trend than E63 and E68. The highest differences was observed in the earliest sowing dates between V4 and the rest of the stages.

	V4	Floral bud	First flowering	First fruiting	Green grains	Colored grains	Maturity
Second order polynomial (quadratic)							
Best-fit values							
B0	4,705	77,16	104,4	148,3	190,0	215,6	250,4
B1	4,217	1,338	0,5276	-2,949	-4,184	-4,171	-7,229
B2	-0,1417	-0,1187	-0,1137	-0,02065	0,001964	-0,02178	0,05141
95% CI (profile likelihood)							
B0	-9,755 to 19,17	63,23 to 91,10	83,82 to 125,0	130,5 to 166,2	175,4 to 204,6	188,1 to 243,1	221,8 to 278,9
B1	1,894 to 6,541	-0,8998 to 3,577	-2,784 to 3,840	-5,817 to -0,08057	-6,526 to -1,843	-8,596 to 0,2532	-11,82 to -2,637
B2	-0,2209 to -0,0626	-0,1949 to -0,0424	-0,2265 to -0,00088	-0,1184 to 0,07706	-0,07780 to 0,0817	-0,1725 to 0,1289	-0,1050 to 0,207
Goodness of Fit							
Degrees of Freedom	6	6	6	6	6	6	6
R squared	0,7669	0,9641	0,9534	0,9773	0,9887	0,9708	0,9779
Sum of Squares	81,11	75,28	164,8	123,6	82,39	294,2	316,9
Sy.x	3,677	3,542	5,242	4,540	3,706	7,002	7,267

E93 Nujet 350



E93 This genotype arrived later and did not participate of the all-sowing dates as was sown from the sowing dates corresponding from beginning of June onward. Thus, only was evaluated in 5 sowing dates. One of the curious aspect in the delayed in the duration of the Emergence-V4 phase suggesting vernalization requirements. However, this delay was not observed n the rest of phases.

	Emergence	V4	Floral bud	First flowering	First fruiting	Green grains	Colored grains	Maturity
Second order polynomial (quadratic)								
Best-fit values								
B0	41,22	73,37	137,1	152,1	230,6	212,7	299,4	354,5
B1	-4,676	-3,686	-5,945	-5,031	-13,27	-7,661	-15,00	-20,55
B2	0,1676	0,07250	0,07714	0,03254	0,2677	0,1026	0,2817	0,4305
95% CI (profile likelihood)								
B0	-541,6 to 624	-91,43 to 238,2	70,76 to 203,3	-96,82 to 401,0	-28,12 to 489,4	-81,70 to 507,1	191,0 to 407,8	165,3 to 543,7
B1	-69,3 to 60,00	-21,97 to 14,60	-13,30 to 1,412	-32,65 to 22,59	-41,99 to 15,44	-40,33 to 25,01	-27,02 to -2,967	-41,55 to 0,4386
B2	-1,566 to 1,90	-0,417 to 0,5627	-0,120 to 0,2743	-0,7079 to 0,7730	-0,5021 to 1,037	-0,773 to 0,9784	-0,0407 to 0,6042	-0,1323 to 0,9932
Goodness of Fit								
Degrees of Freedom	2	2	2	2	2	2	2	2
R squared	0,4364	0,7884	0,9953	0,9582	0,9450	0,9436	0,9944	0,9841
Sum of Squares	261,5	20,91	3,383	47,69	51,54	66,73	9,044	27,55
Sy.x	11,43	3,233	1,301	4,883	5,077	5,776	2,126	3,711

CRONOCARINATA: A SIMPLE MODEL FOR PREDICTING PHENOLOGY

Initial screen of the CRONOCARINATA model in excel format

CHRONOCARINATA

Genotype	Avanza	
Location	**Province**	**Site**
	Buenos Aires	Adolfo Alsina
Sowing date	**Month**	**Day**
	April	3

Select your option

Stress	Probability (%)
Moderate fros	82%
Extreme fros	0%
Moderate heat sh	0%
Extreme heat she	0%

Abbreviations

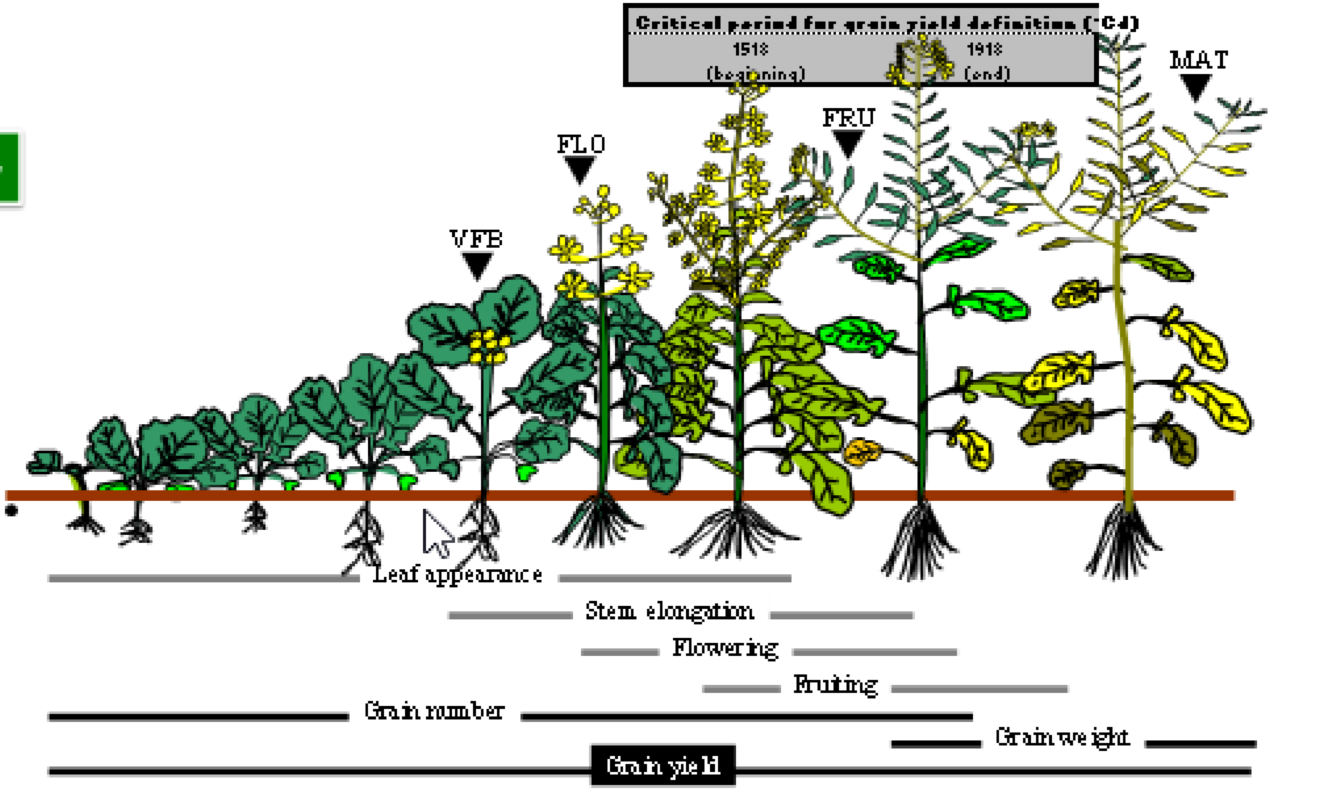
Phenology (CETIOM scale; Arnoud, 1989)

V4: rosette with 4 emerged leaves; VFB: visible floral bud; FLO: first flowering;
FRU: first fruiting; GG: green grains; CG: colored grains; MAT: maturity

TT: thermal time from emergence (°Cd; base temperature: 0°C)

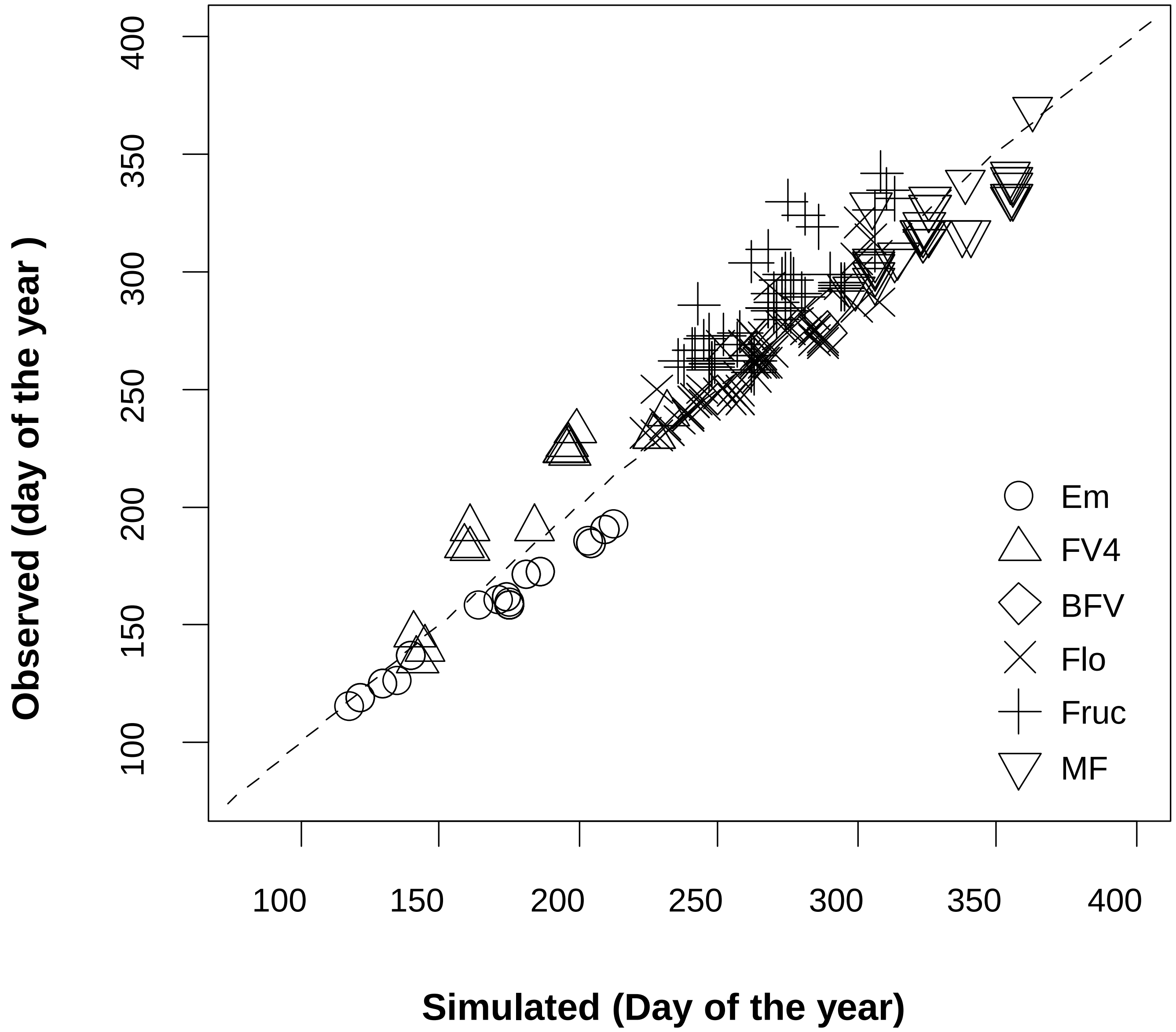
AWC: soil available water content (%)

+/- represents one standard deviation



	EME	+/-	V4	+/-	VFB	+/-	FLO	+/-	FRU	+/-	GG	+/-	CG	+/-	MAT	+/-
Date	11-abr	1	11-may	4	31-jul	11	29-ago	9	17-sep	8	####	7	14-nov	6	17-nov	6
TT from emergence (°Cd)			441	4	1148	3	1418	4	1643	6	1818	3	2548	7	2594	5
AWC (%)	52	19	67	21	63	20	61	21	56	20	58	19	57	19	56	16

CHRONOCARINATA: Validation using independent values



The model was validated using independent data provided by NUSEED (Ing Orlando Vellaz). The independent data were originated in experiments carried out by the company between 2018 and 2021 for Avanza 641 and Nujet 400 in different locations of Argentina.

The model showed an error of prediction that was variable depending on the phenological phases. At first flowering the prediction error was of 9 days.

Stage	RMSE	RMSE (%)	bias	rcoeff	sb
Em	13.2	8	-11.9	99.2	142.3
FV4	23.0	12	-19	91.7	361
BFV	11.4	4	10.5	100	110.2
Flo	9.2	4	0.2	88.8	0.036
Fruc	19.5	7	-15.3	82.2	232.8
MF	12.8	4	8.4	85.7	70.3

CHRONOCARINATA: Next Steps

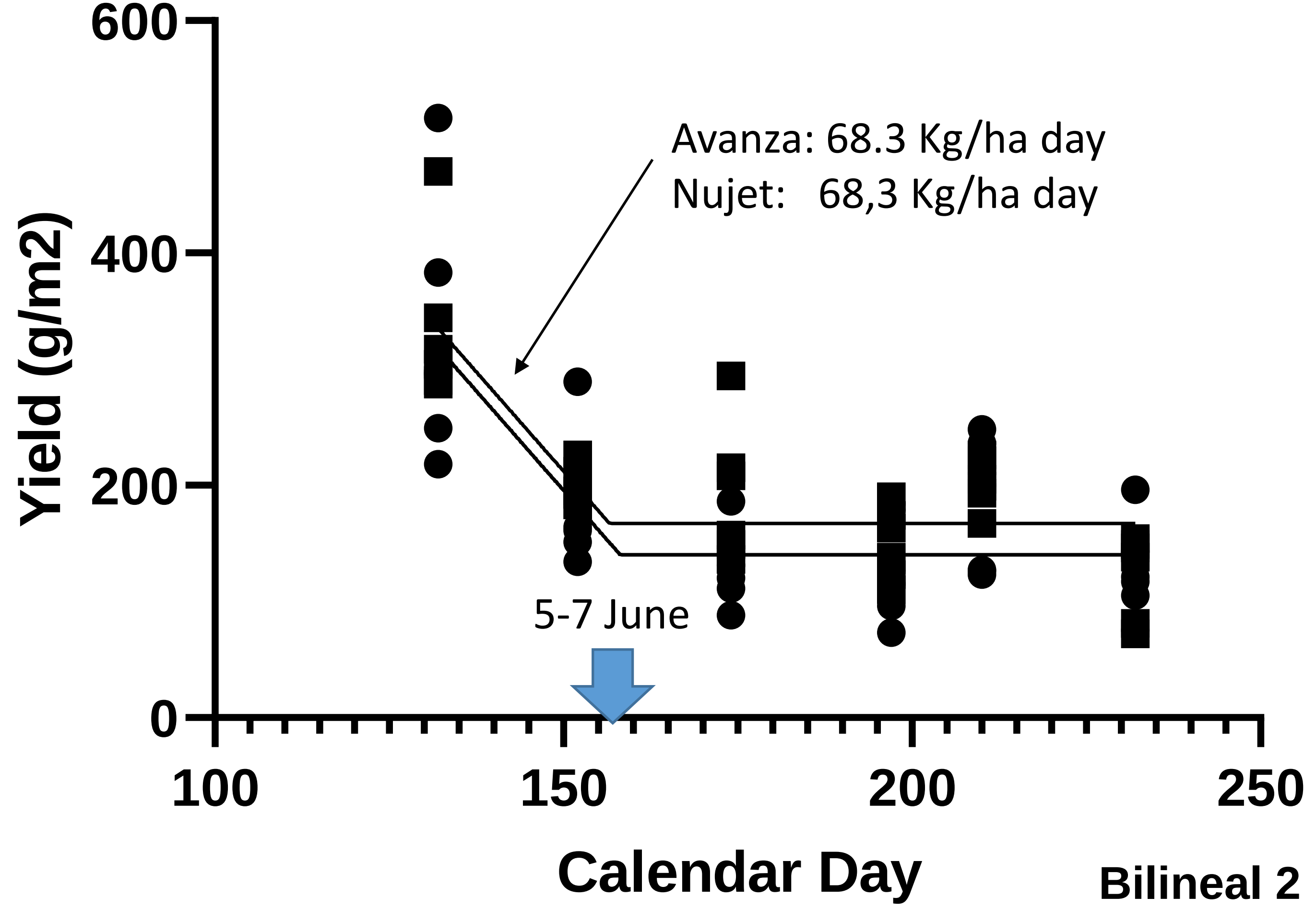
During 2023 the experiments for phenology determination will be repeated for Nujet 350 (we have some few data from 2022). We will see the experiments in the field

The data of both years 2021 and 2022 were used together to built new algorithms and running those with 30 year of climatic data (from NASA POWER) in more than 200 locations of Argentina. This model depending on the objective of the company can be replicated in different countries. To do that it is necessary to have phenological experiments in those countries.

During 2023/24 the model (that is actually in an Excel format) will be programmed to be available in a WEB site of the FAUBA domain with public free access (at least for the commercial cultivars).

Yield losses by changes in sowing dates

Avanza & Nujet



Avanza
Nujet400

Yield losses per day of delaying in sowing dates

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

Biomass production, partitioning water availability into the soil

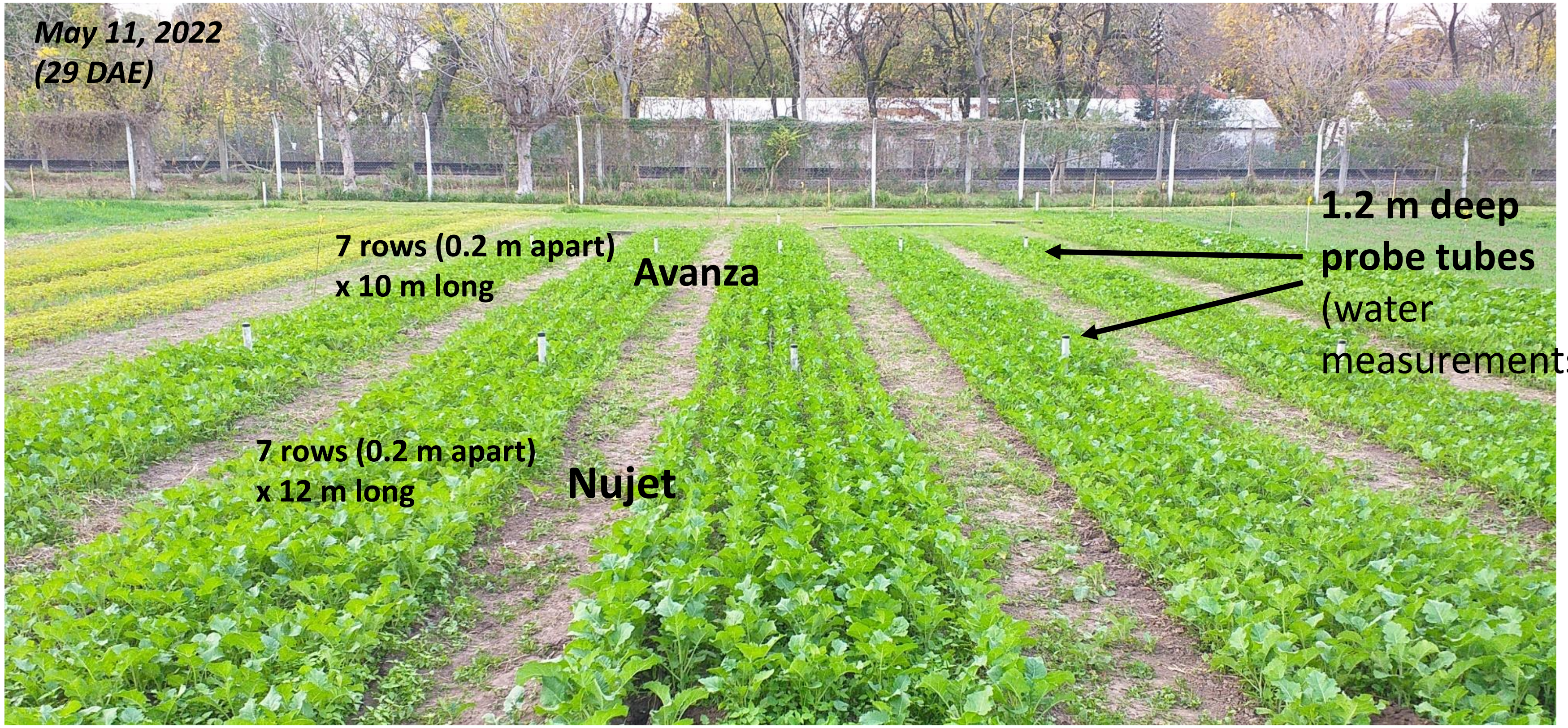
Biomass and physiological components

Experiments at the School of Agronomy, University of Buenos Aires (34°36’S 58°26’W)
Soil: Typical Argiudoll with a strong clayey horizon (Bt) at 40 cm depth. *Same plot than in 2021*

Nujet 400 (hybrid) and Avanza 641 (OP variety) with 5 replicates
Sowing date: April 6, 2022 *(78 days earlier than 2021)* Planting rate: 100 plants/m2
Husbandry: irrigated and fertilized (up to 100 kg N available/ha), cletodim and preventive fungicide in V6. Foliar fertilizer (June 28, 76 DAE) to reverse foliar cold damage.

More problems with weeds and early frost than in 2021

May 31, 2022 (49 DAE)



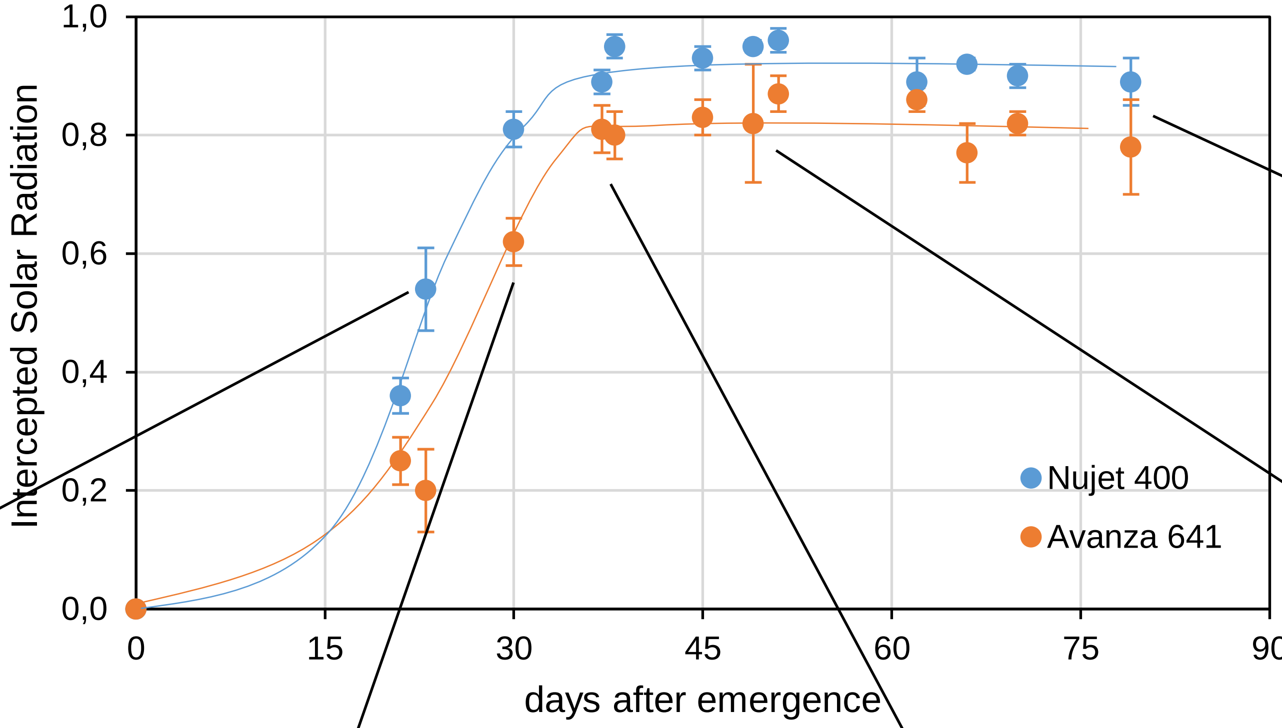
Canopy light capture 2022

-Quick soil coverage (from 15 to 40 DAE) in mid-April to mid-May
-Light interception efficiency (>90%) by late May for Nujet but Avanza is less efficient (<90%)
-Leaf yellowing at late June (low temp +dry soil?)

-Similar crop phenology for both genotypes
But different plant growth
Nujet > Avanza

Sowing date: April 6, 2022
Emergence: April 12

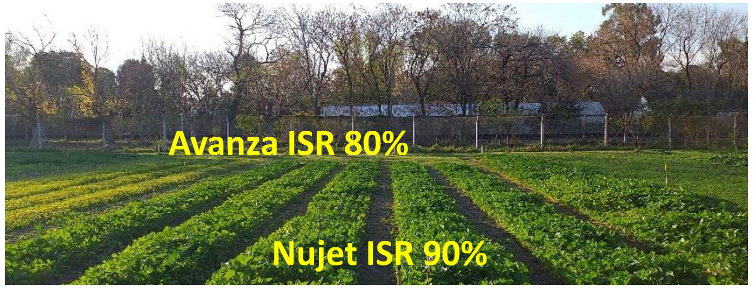
Rosette (V4)
Nujet: May 2; Avanza: April 30



May 4 (22 DAE)

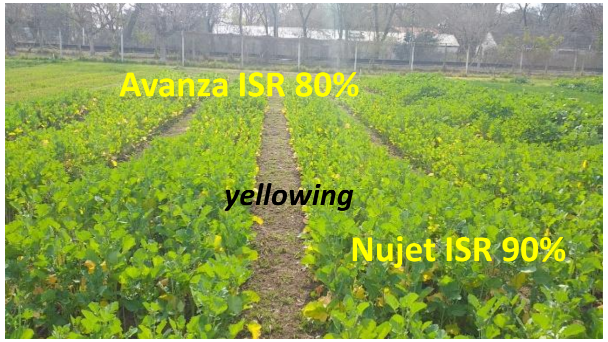
May 11, 2022 (29 DAE)

May 21, 2022 (39 DAE)

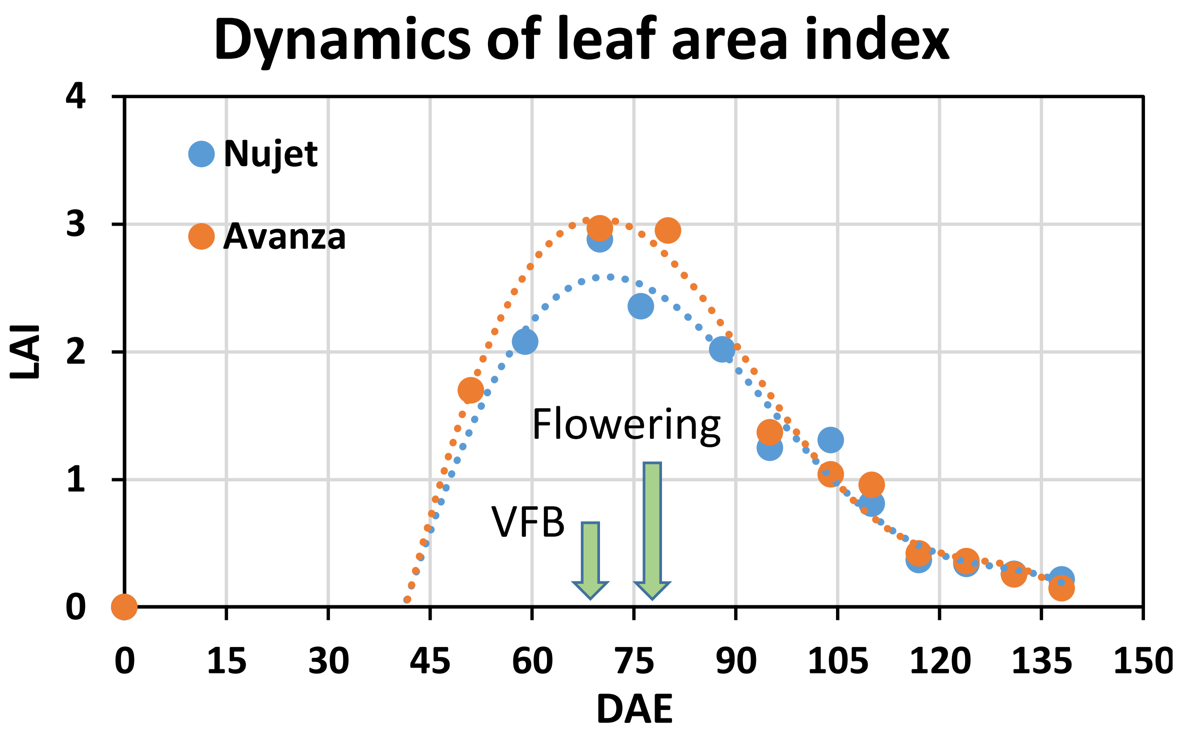


May 31, 2022 (49 DAE)

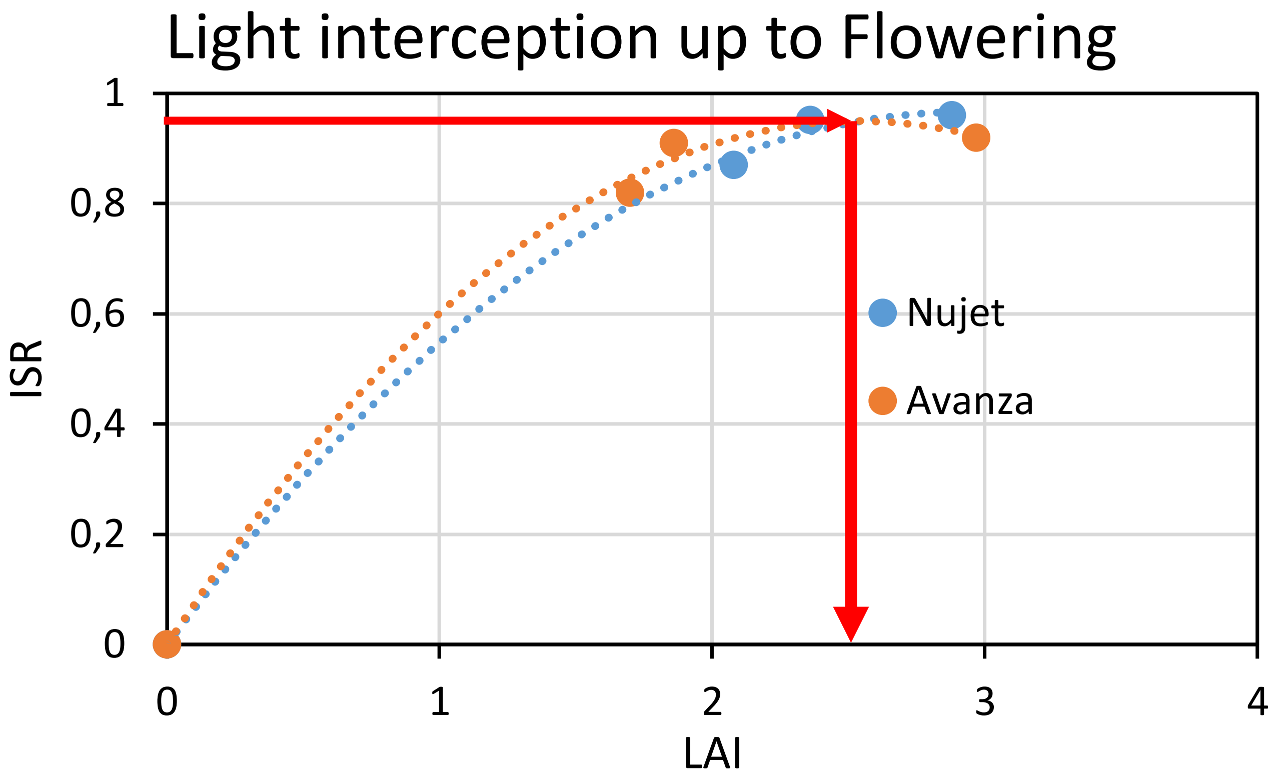
June 29, 2022 (78 DAE)



Leaf area index 2021



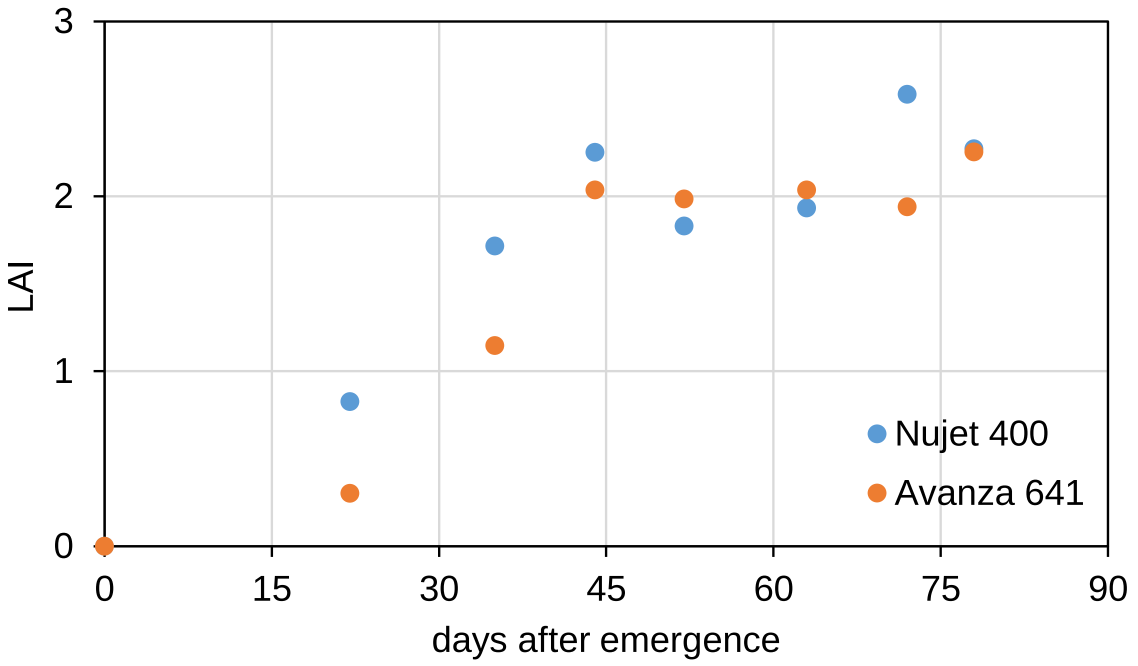
-Maximum LAI (=3) at visible floral bud
-Rapid decrease in LAI from flowering
(shading and replacing by siliques area)

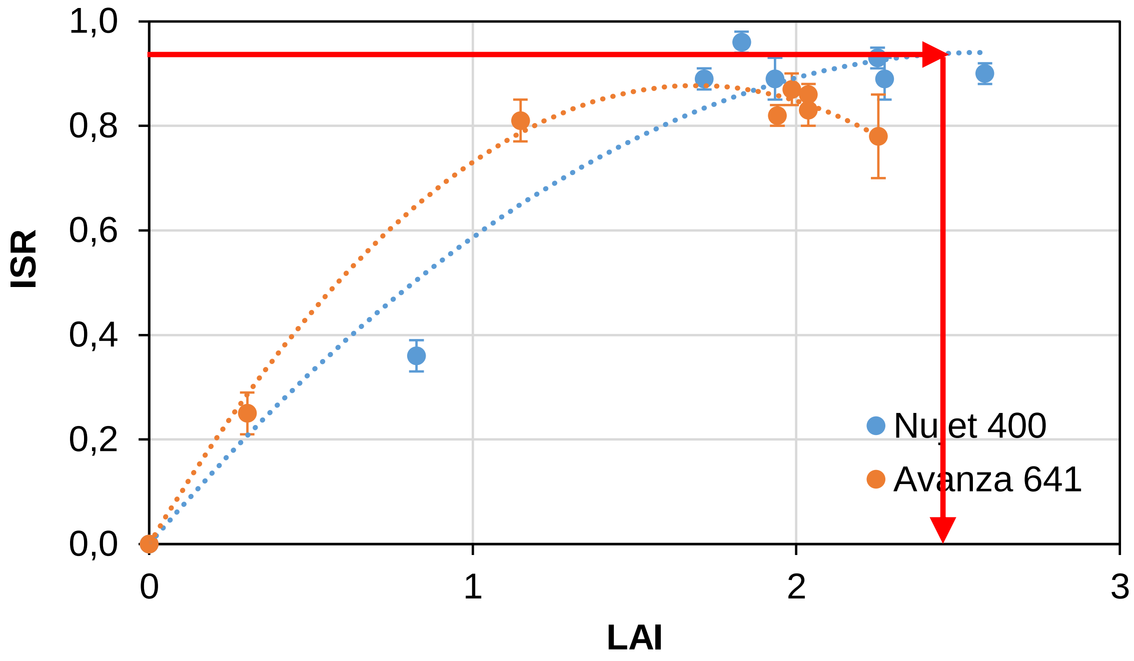


-Maximum intercepted solar radiation (ISR) at LAI=2.5-3
(more early data points are needed)

-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)

Leaf area index and intercepted solar radiation 2022



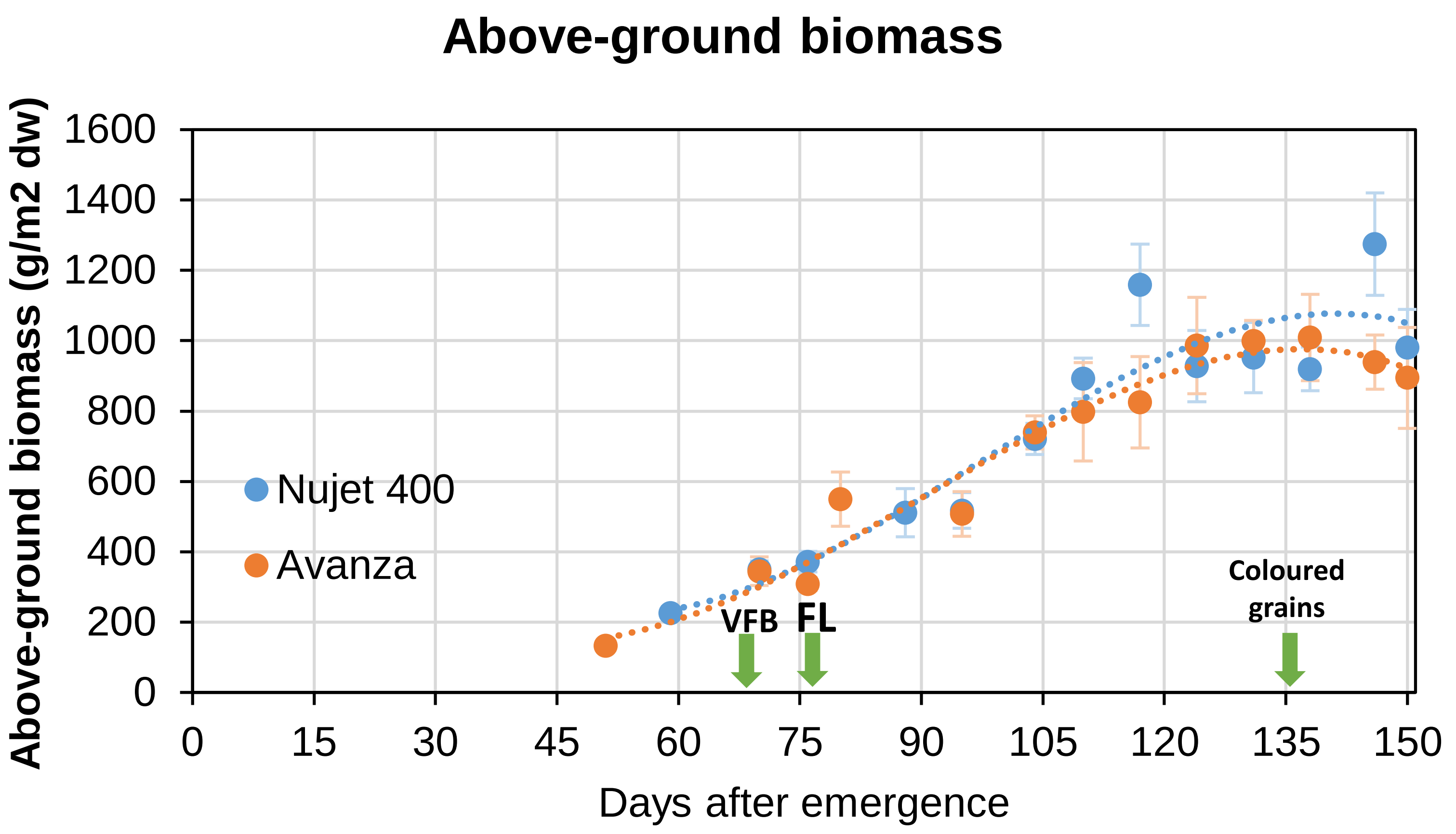


-Quick initial leaf growth (up to 45 DAE) and then stabilizes around LAI=2-2.5

-Nujet: Intercepted solar radiation (ISR) >95% at LAI=2.5
(more early data points than 2021)
-Avanza: poor leaf growth, ISR around 85% at LAI=2

-Maximum light capture efficiency (>95% ISR) with LAI = 2.5-3 is typical for Brassicas (and other broadleaf crops)

Aerial biomass growth 2021



Aerial biomass at Flowering:

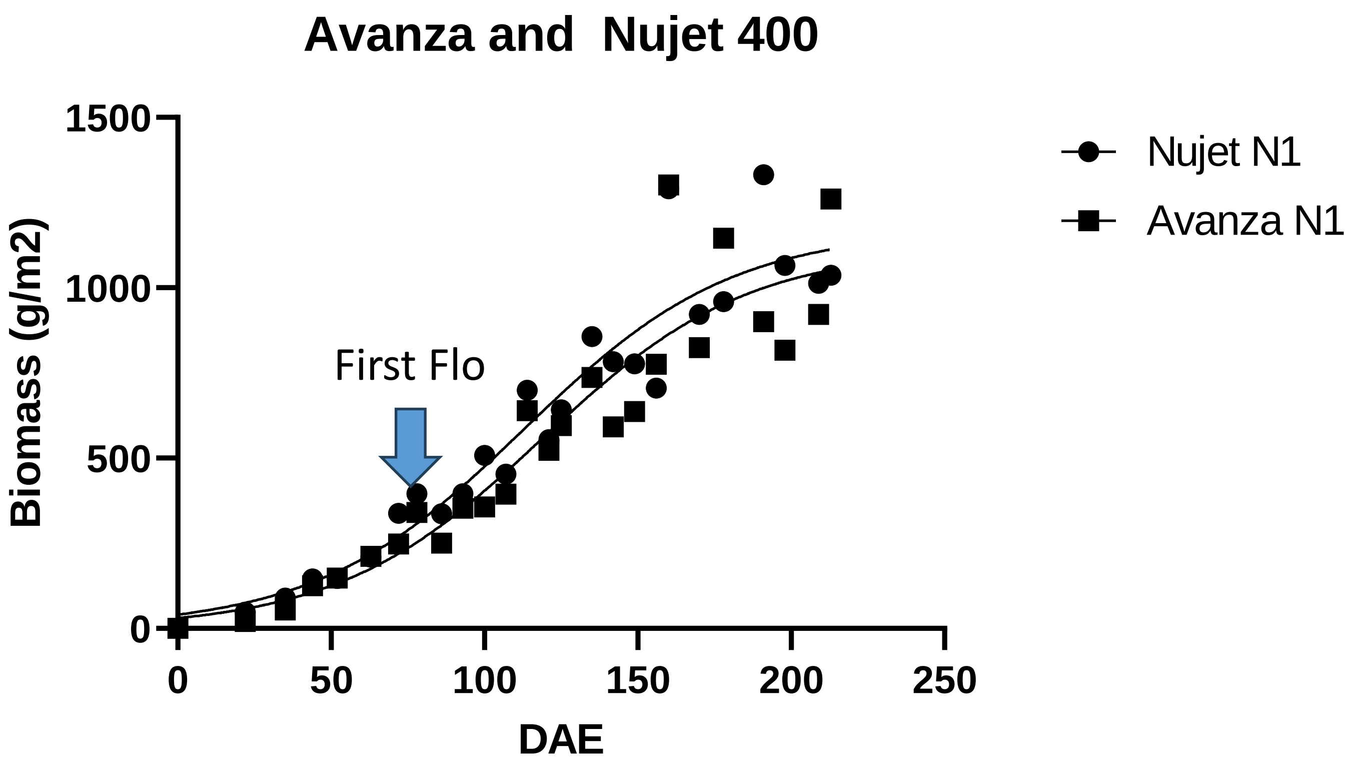
Aerial Biomass at 76 DAE Begining of Flowering	Kg/ha DW
Nujet 400	3700 ± 280
Avanza	3100 ± 180

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)

Aerial biomass growth 2022

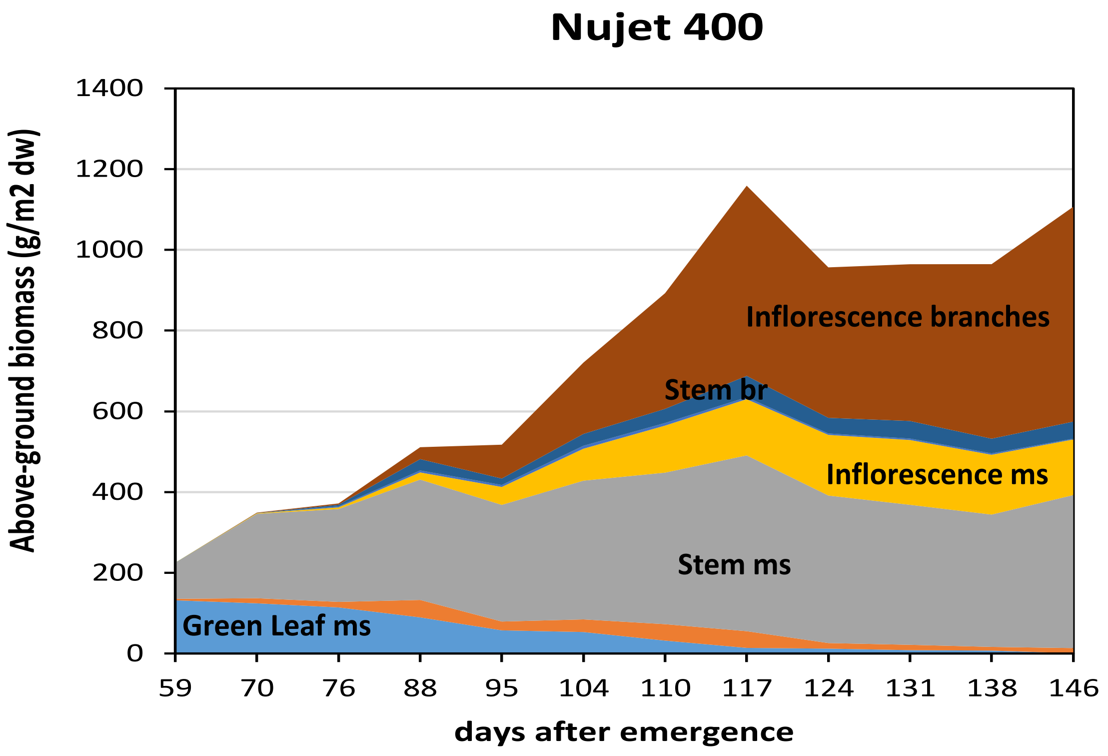


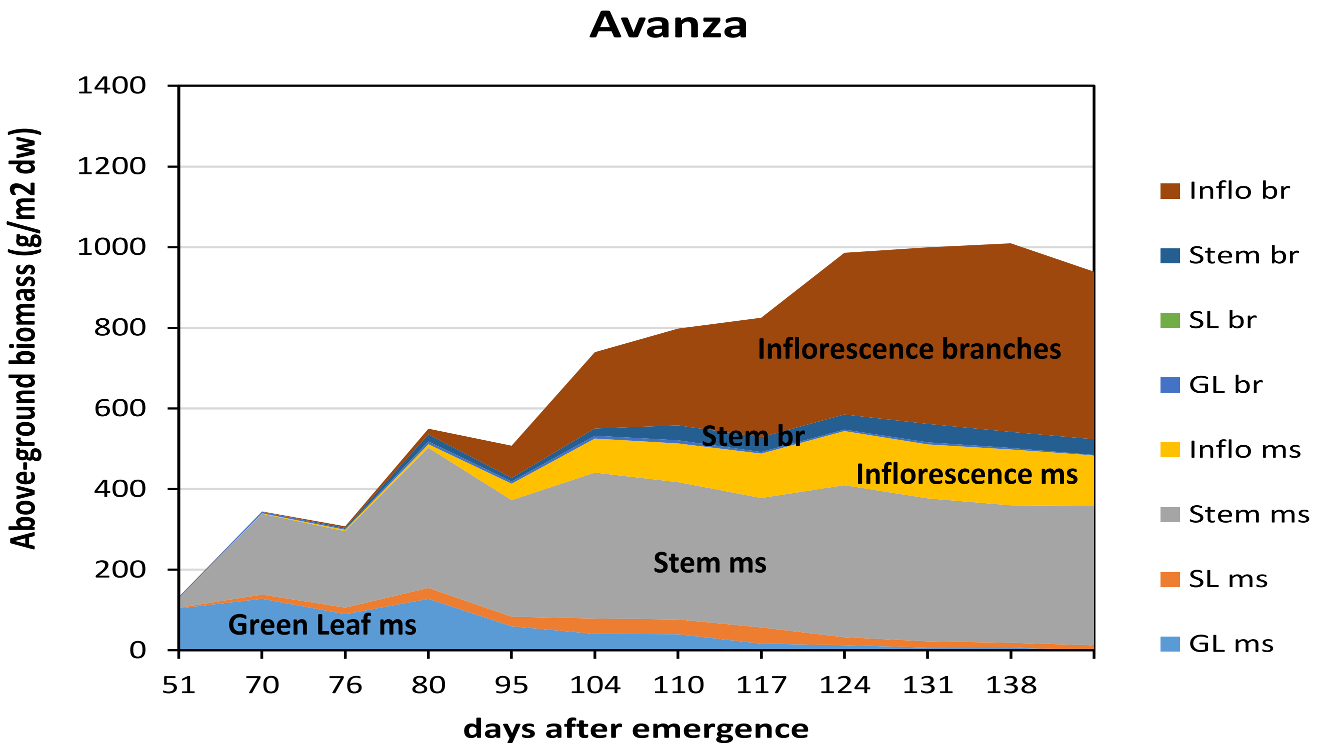
-Typical sigmoid pattern
-Only 1/3 of biomass grows until flowering, the remaining 2/3 grow after flowering
-Both genotypes reach similar biomass at harvest

	Nujet N1	Avanza N1
Logistic growth		
Best-fit values		
YM	1171	1114
Y0	40,57	30,75
k	0,02946	0,02998
Xint	33,95	33,36
95% CI (profile likelihood)		
YM	1013 to 1463	928,3 to 1577
Y0	11,60 to 95,82	5,029 to 94,18
k	0,02002 to 0,04223	0,01804 to 0,04733
Xint	23,68 to 49,96	21,13 to 55,43
Goodness of Fit		
Degrees of Freedom	23	23
R squared	0,9117	0,8754
Sum of Squares	328475	442041
Sy.x	119,5	138,6
Number of points		
# of X values	26	26
# Y values analyzed	26	26

Biomass allocation 2021

ms: from main stem
br: from branches





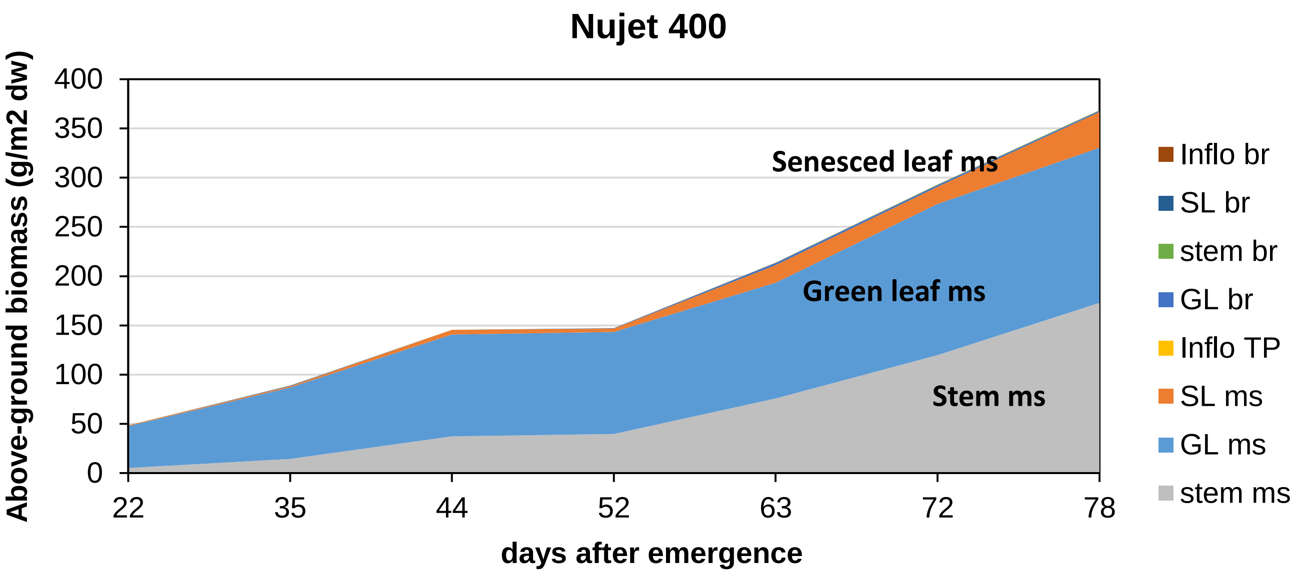
-Similar biomass allocation in both genotypes

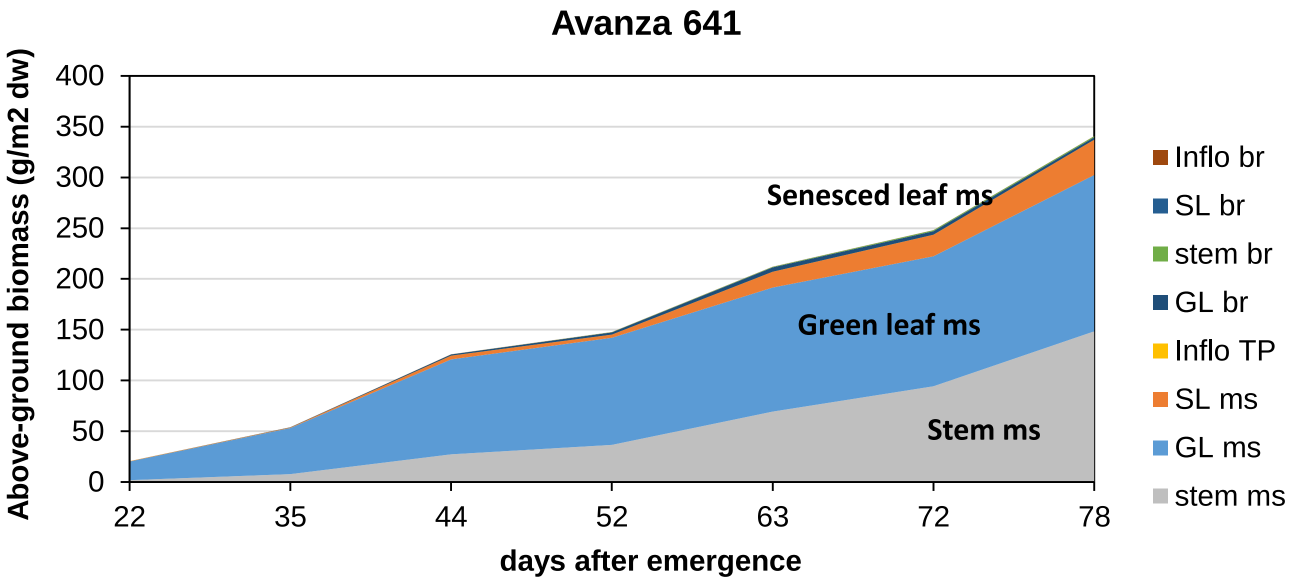
-Most of biomass is in branches (45%)

-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 %**

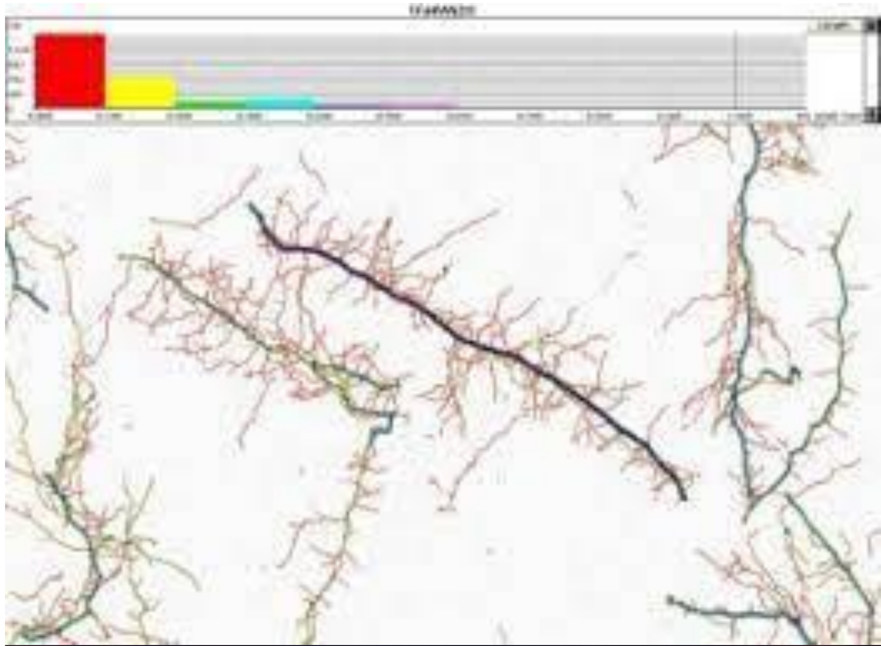
Biomass allocation 2022

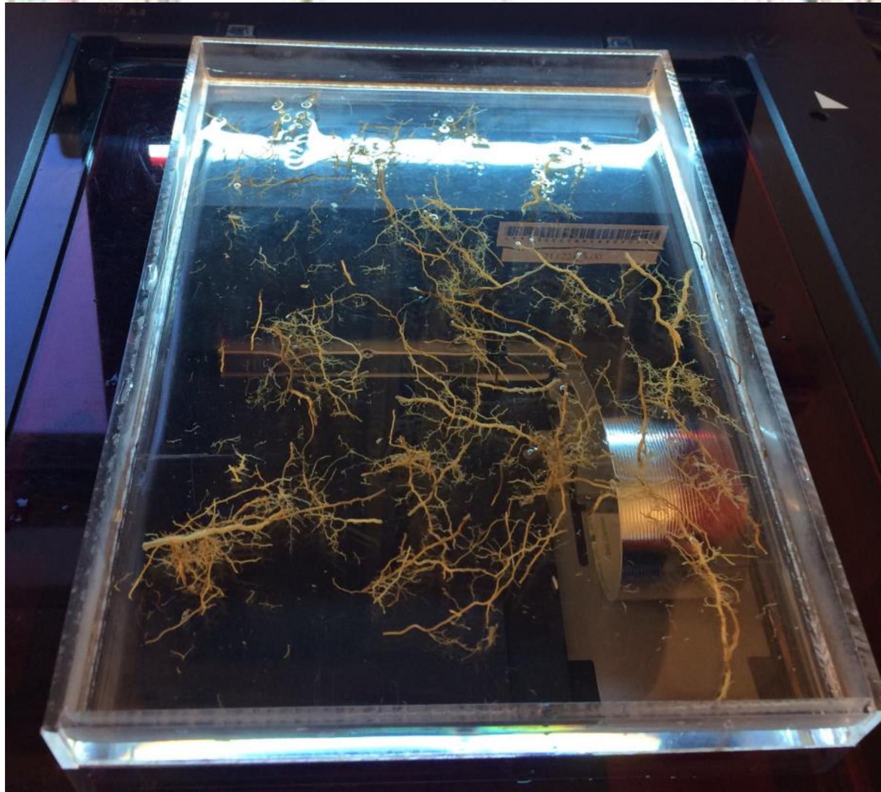




-Early leaf senescence since mid June (from 60 DAE)

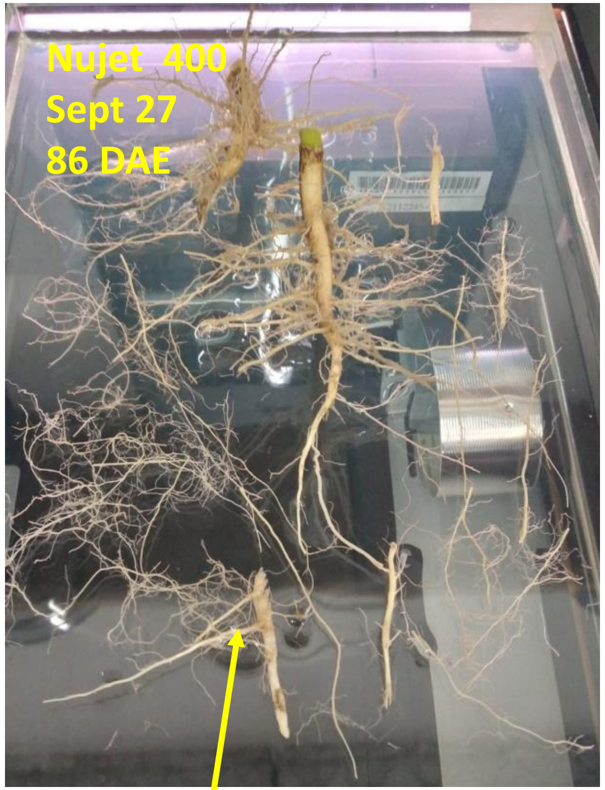
Root lenght: Winrhizo scanner



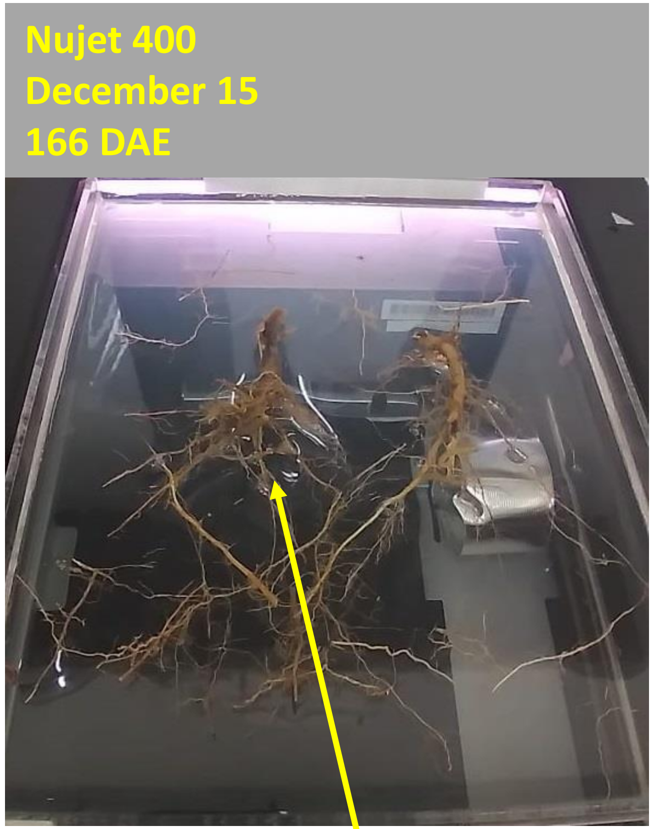


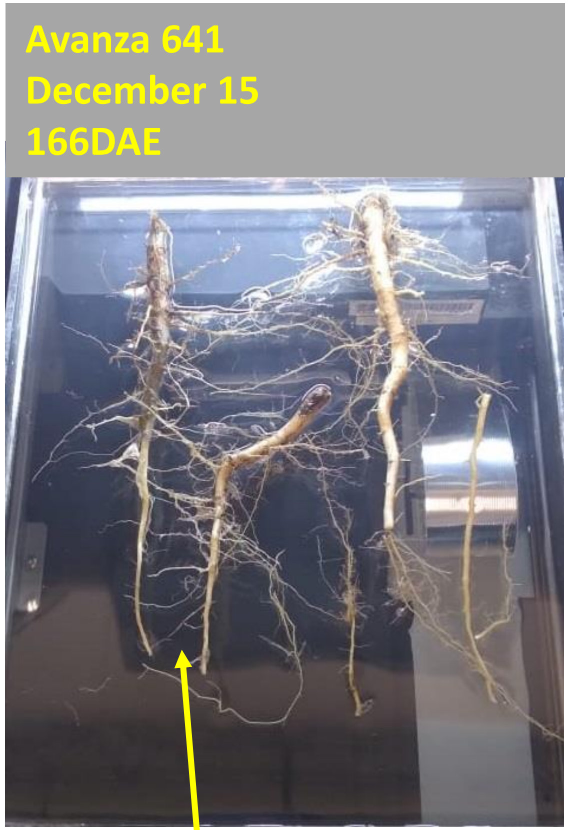
Root lenght 2022

Around the beginning of Flowering



After maturity





Shallow lateral roots at 90º

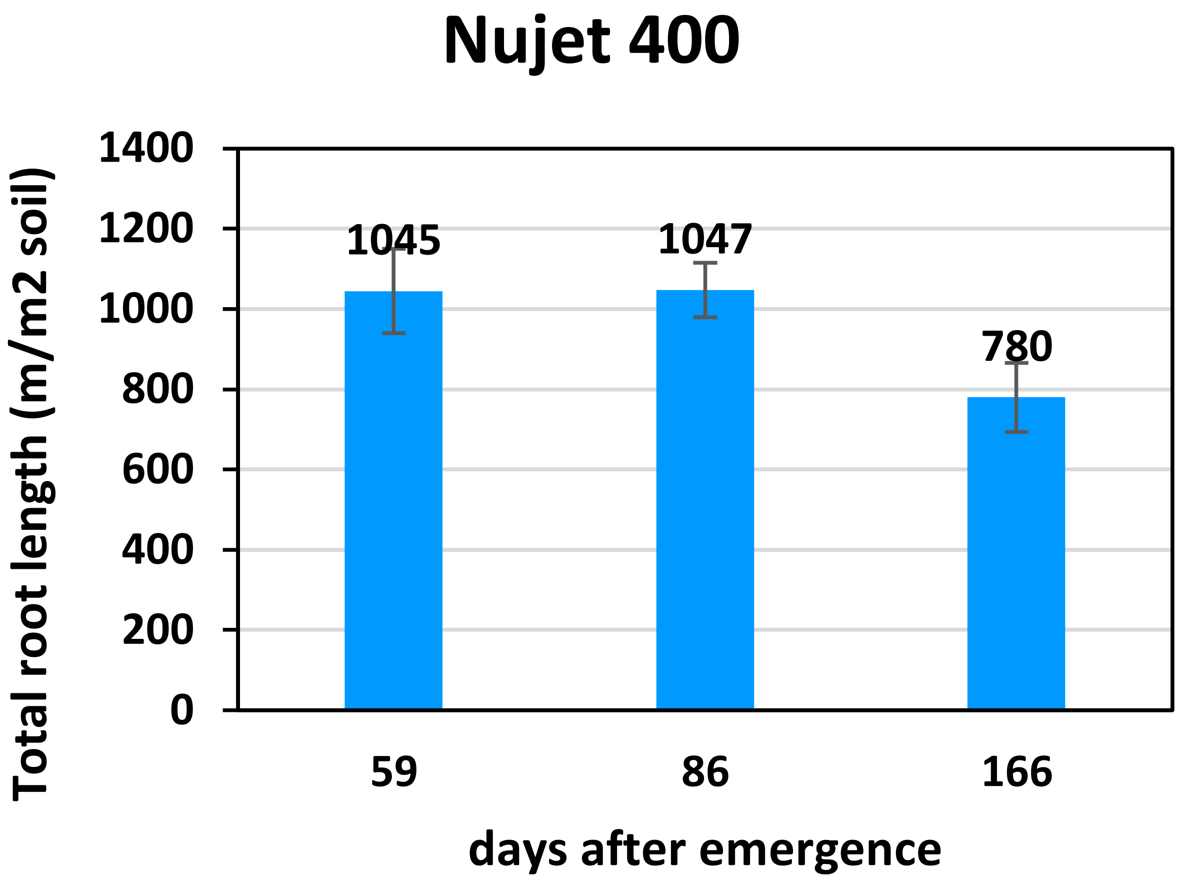
Fine, bright root hairs

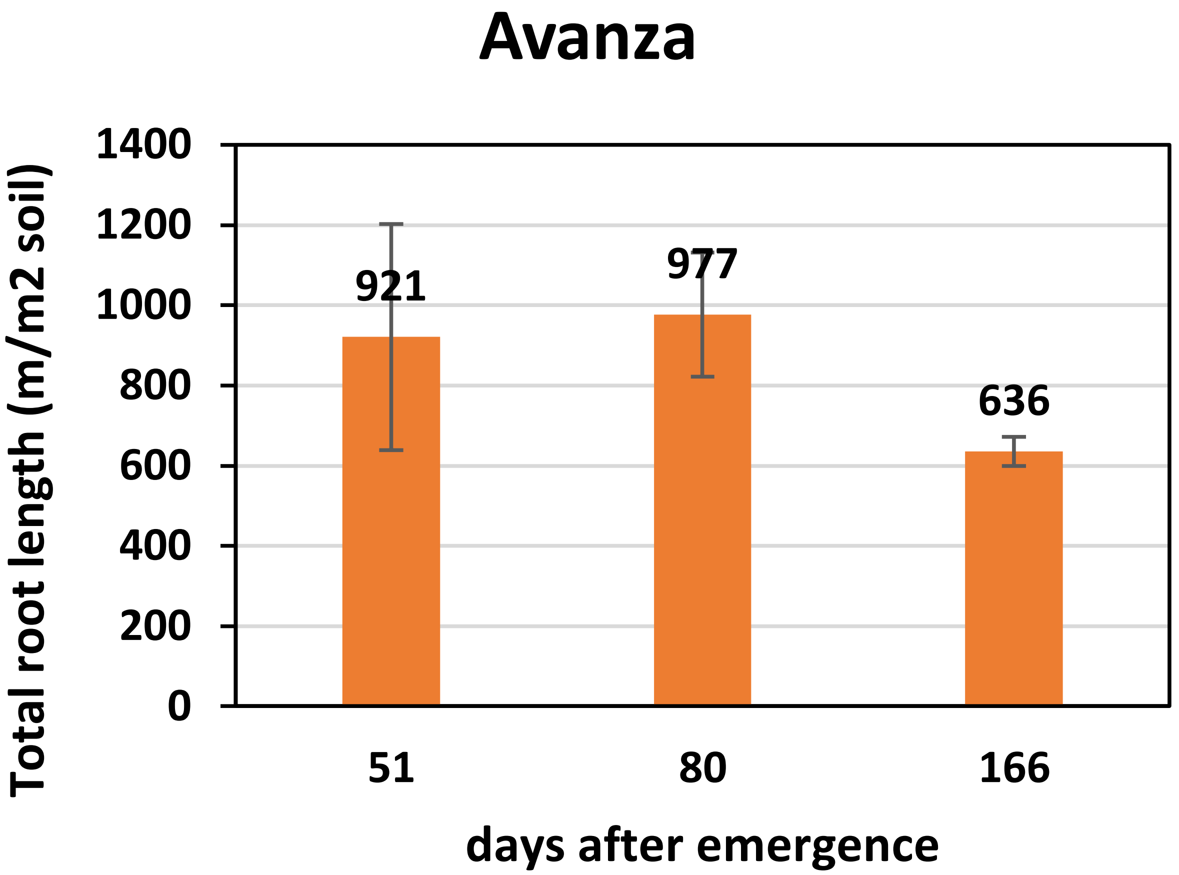
Heavy, long taproot

Dark brown colour

Few root hairs

Root lenght 2021

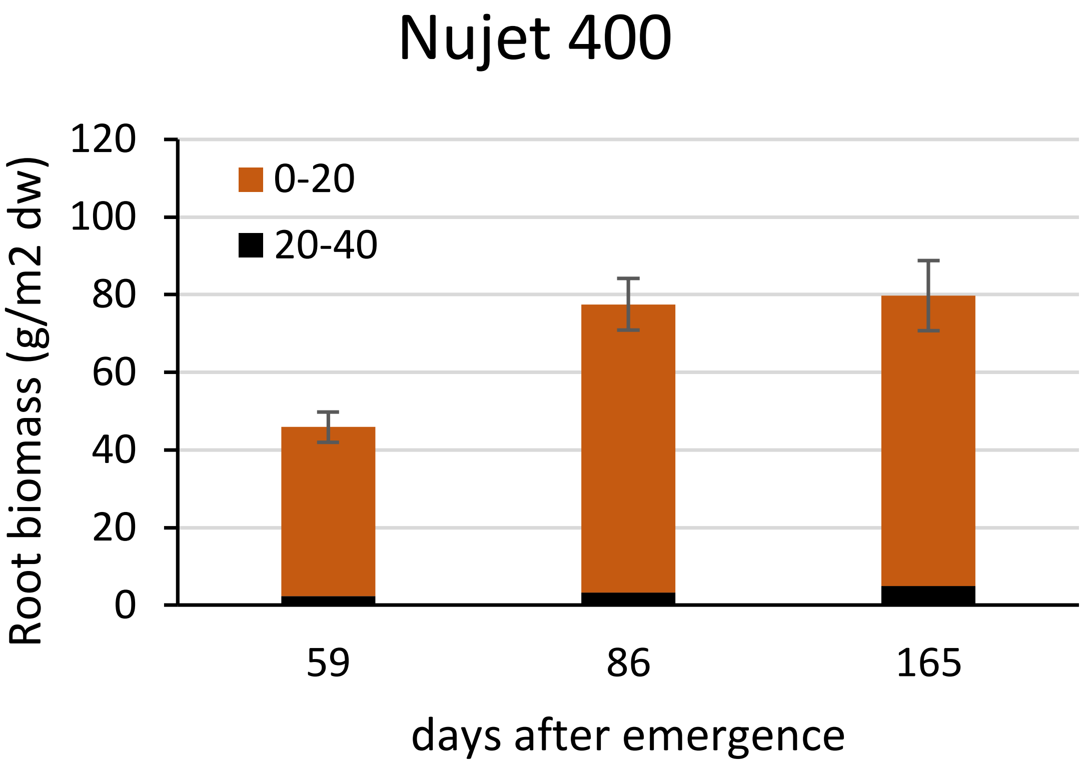


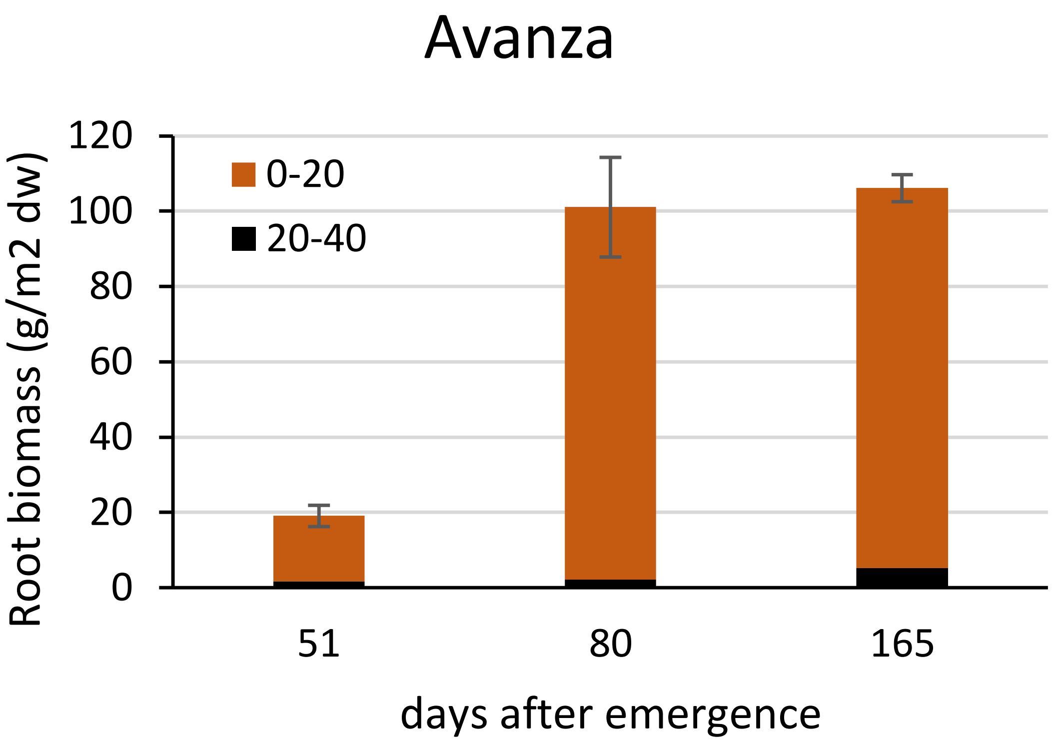


At flowering ≈ 1 kilometer roots per m^2 soil
(lower than 2-3 km/m^2 reported in canola)
Zhang et al (2005) AJAR

Reduction of root length post- flowering
After maturity ≈ 0.6-0.8 kilometer roots per m^2 soil

Root biomass 2021



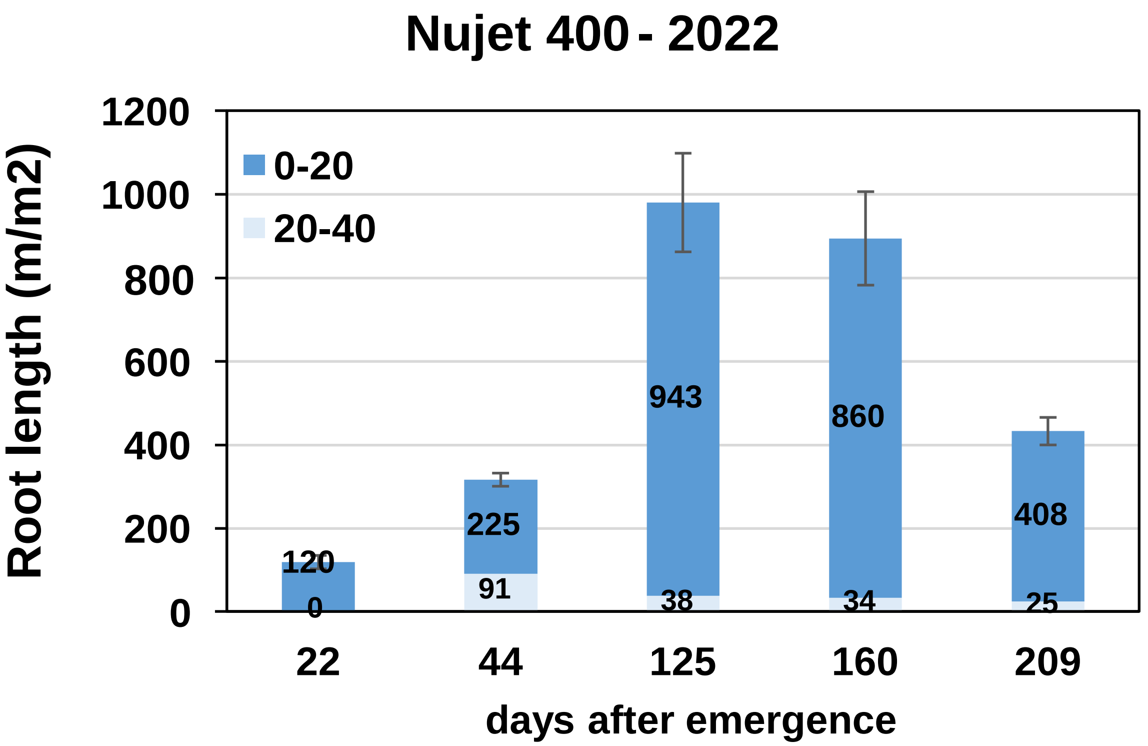


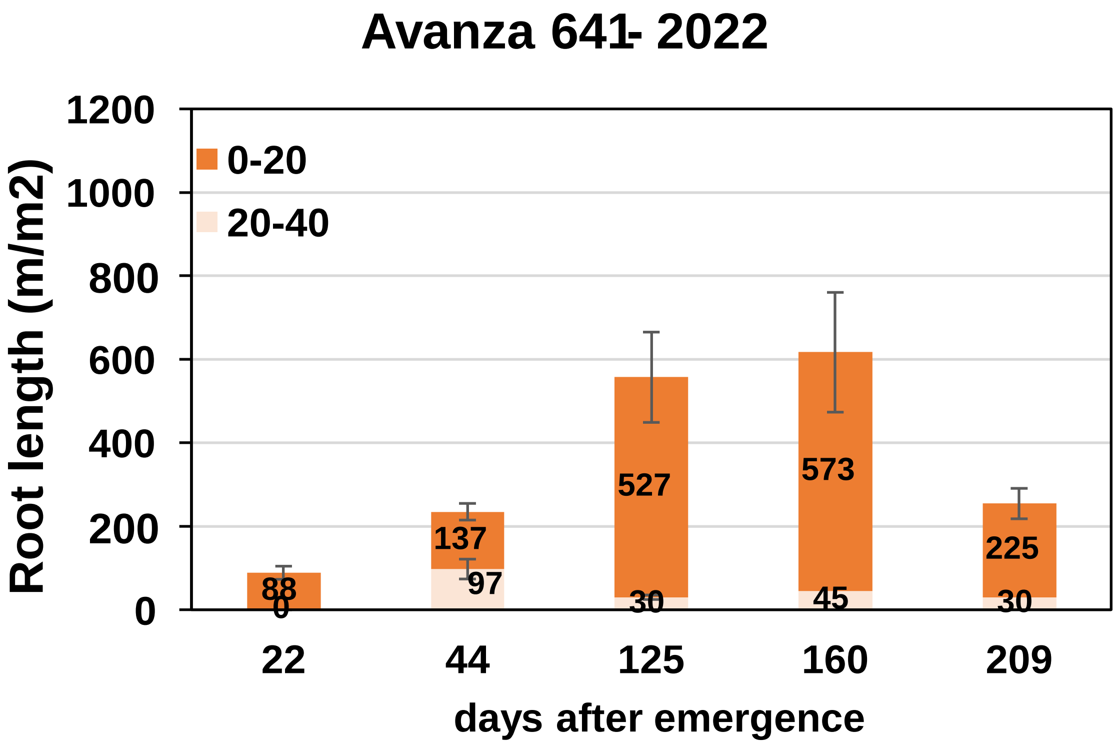
-Roots were mainly in the topsoil and did not deepen beyond 0.4 m (strong Bt clay horizon)
-At flowering ≈ 800-1000 kg/ha of dry biomass allocated in roots (20-30% of aerial biomass)
-Root biomass did not increase post-flowering (but aerial biomass increase twice)

Total root weight similar to B. carinata in Uruguay (85-140 g/m2) Mazzilli & Ernst (2021) and mustard (50-80 g/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 Length 2022

V4= 22 DAE V6= 44 DAE **FL= 125 DAE** Grain-filling = 160 DAE Maturity = 209 DAE





-A complete picture of root development and death (compared to only 3 samplings in 2021)

-**At flowering ~ 1 kilometer root per m^2** (as in 2021 but lower than 2-3 km/m^2 reported in canola (Zhang et al 2005) AJAR

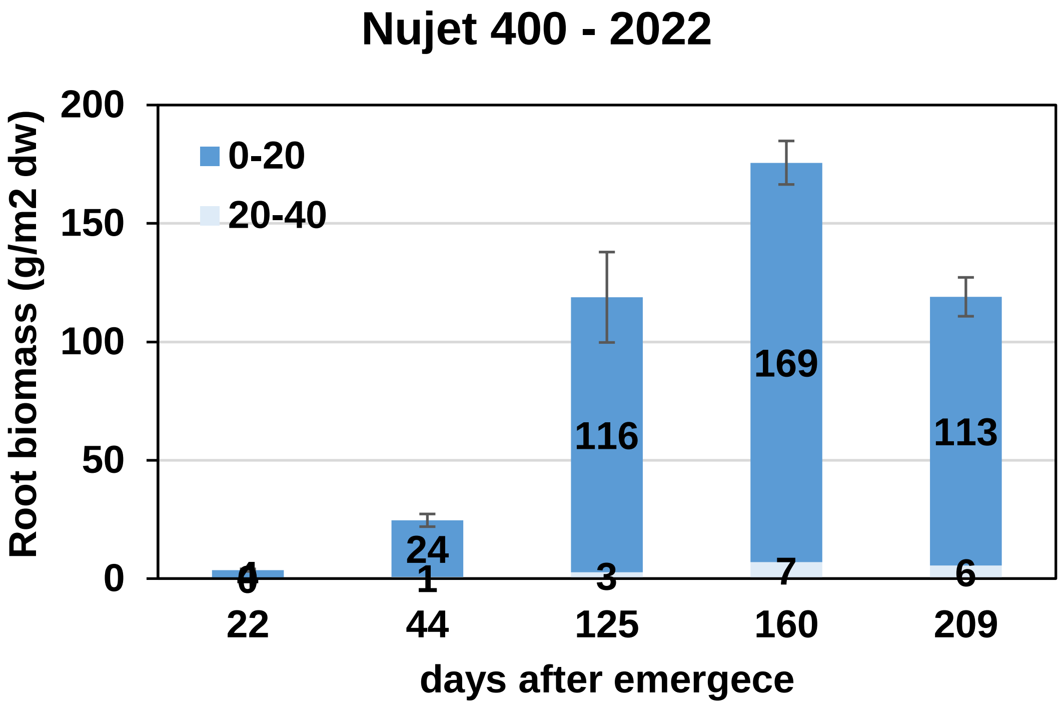
-Less root length for Avanza 641

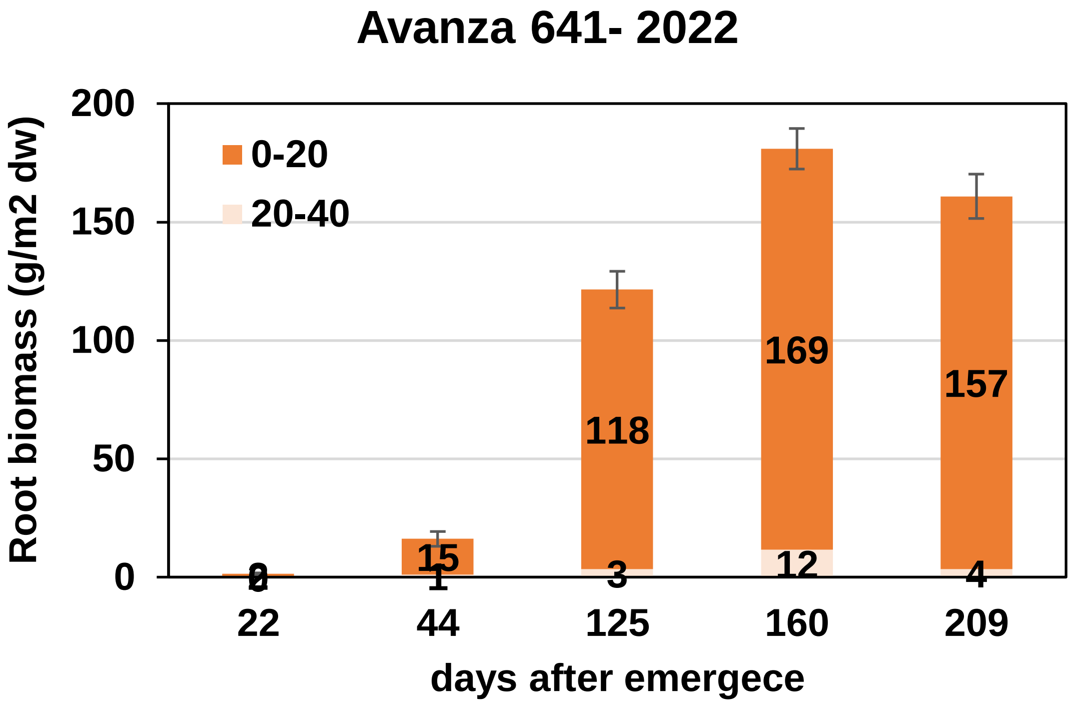
-**Root length does not increase between flowering and grain filling**

-Then, root length was halved at maturity (0.3-0.4 kilometer/m^2)

Root Biomass 2022

V4= 22 DAE   V6= 44 DAE   **FL= 125 DAE**   Grain-filling = 160 DAE   Maturity = 209 DAE





-Roots are mainly in the topsoil, with little (but not null) growth beyond 0.4 m (strong Bt clay horizon and drip irrigation)

-**At flowering ~1200 kg/ha of dry biomass allocated in roots (equal to 20-25% of aerial biomass). Shoot/root ratio= 4-5**

-**Root biomass increase by 50% during grain filling period** (in contrast to rooth length, and not evaluated in 2021)

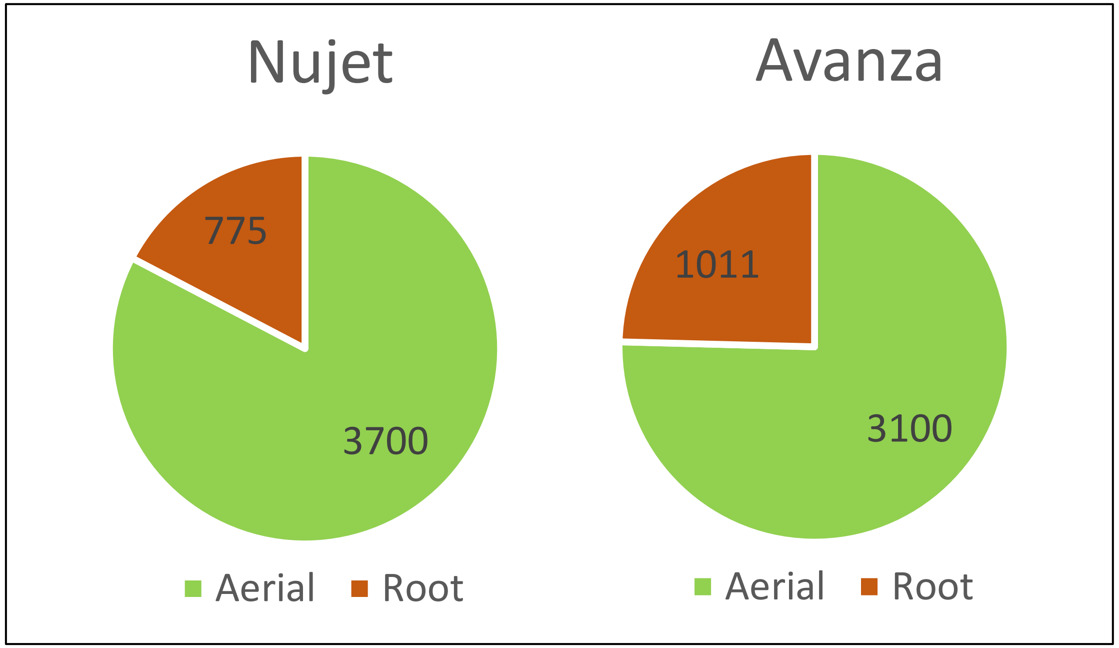
-**Total root biomass at maturity ~1200-1600 kg/ha. Shoot/root ratio= 8-9**

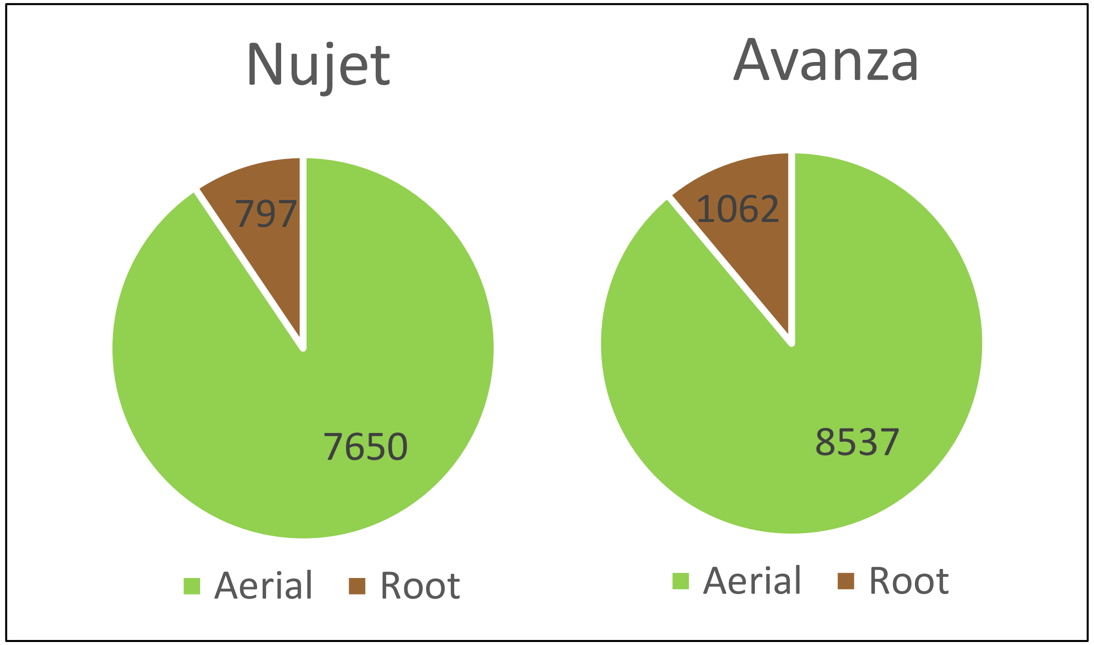
-Total root biomass (120-160 g/m^2) is similar to *B. carinata* in Uruguay (85-140 g/m^2) Mazzilli & Ernst (2021) and mustard (50-80 g/m^2) Gan et al (2009) CJPS and within the range for canola (100-160 g/m^2) Zhang et al (2005) AJAR, Gan et al (2009) CJPS, Wu et al (2020) FPS

-Shoot/root ratio at harvest (8-9) is in the range of *B. carinata* in Bs As 2021 (8-10) and Uruguay (7.5-11) Mazzilli & Ernst (2021)

Root/aerial ratio

-Roots contribute ca. 1.5 tons/ha of 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





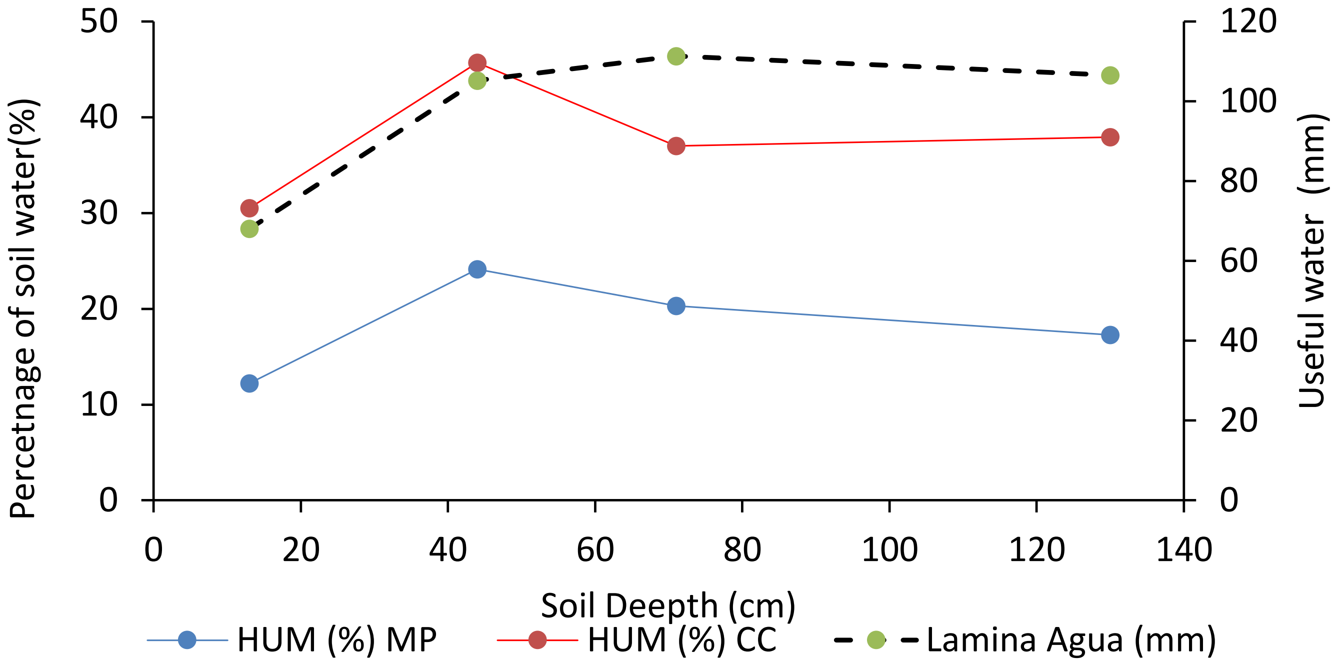
Total Biomass at Flowering	**Nujet**	**Avanza**
Aerial (Kg/ha DW)	**3700 ± 280**	**3100 ± 180**
Root (Kg/ha DW)	**775 ± 60**	**1011± 135**
Root/aerial ratio	**0.21**	**0.33**

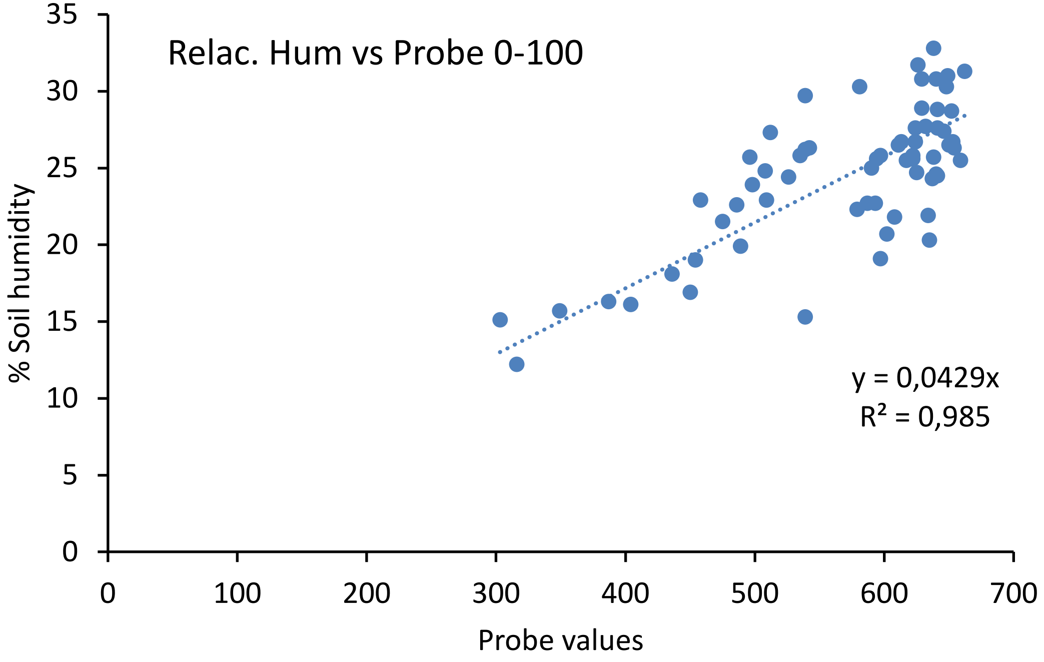
Total Biomass (15 days after Maturity)	**Nujet**	**Avanza**
Aerial (Kg/ha DW)	**7650 ± 1154**	**8537 ± 1190**
Root (Kg/ha DW)	**797 ± 97**	**1062 ± 37**
Root/aerial ratio	**0.10**	**0.12**

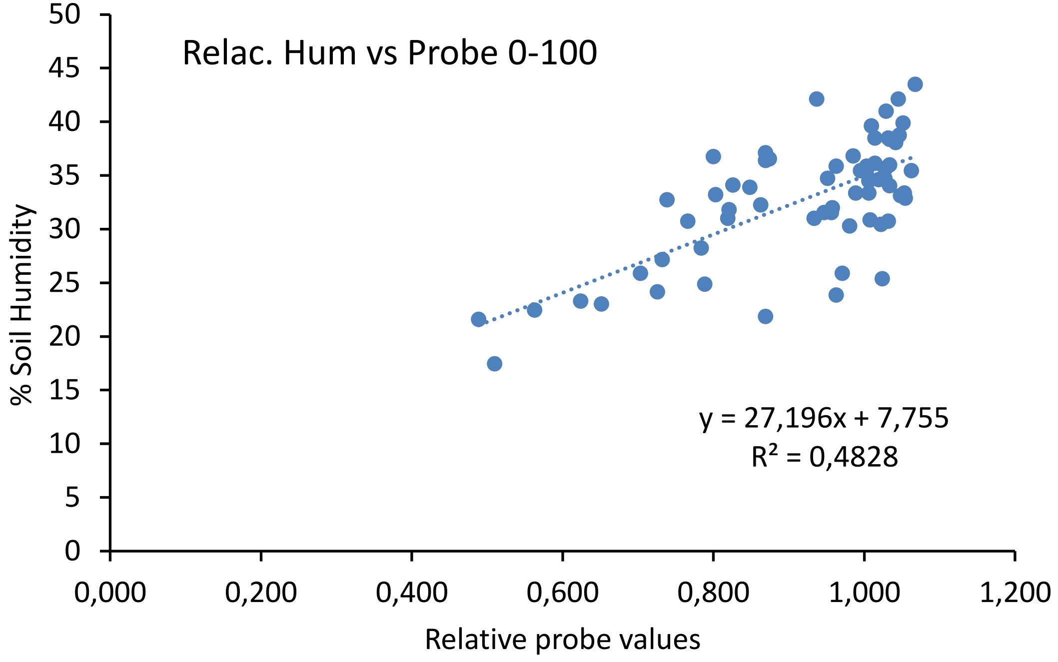
Shoot/root ratio at harvest (8-10) is in the range of B. carinata in Uruguay (7.5-11) Mazzilli & Ernst (2021)

Soil water contents: Upper and lower limits

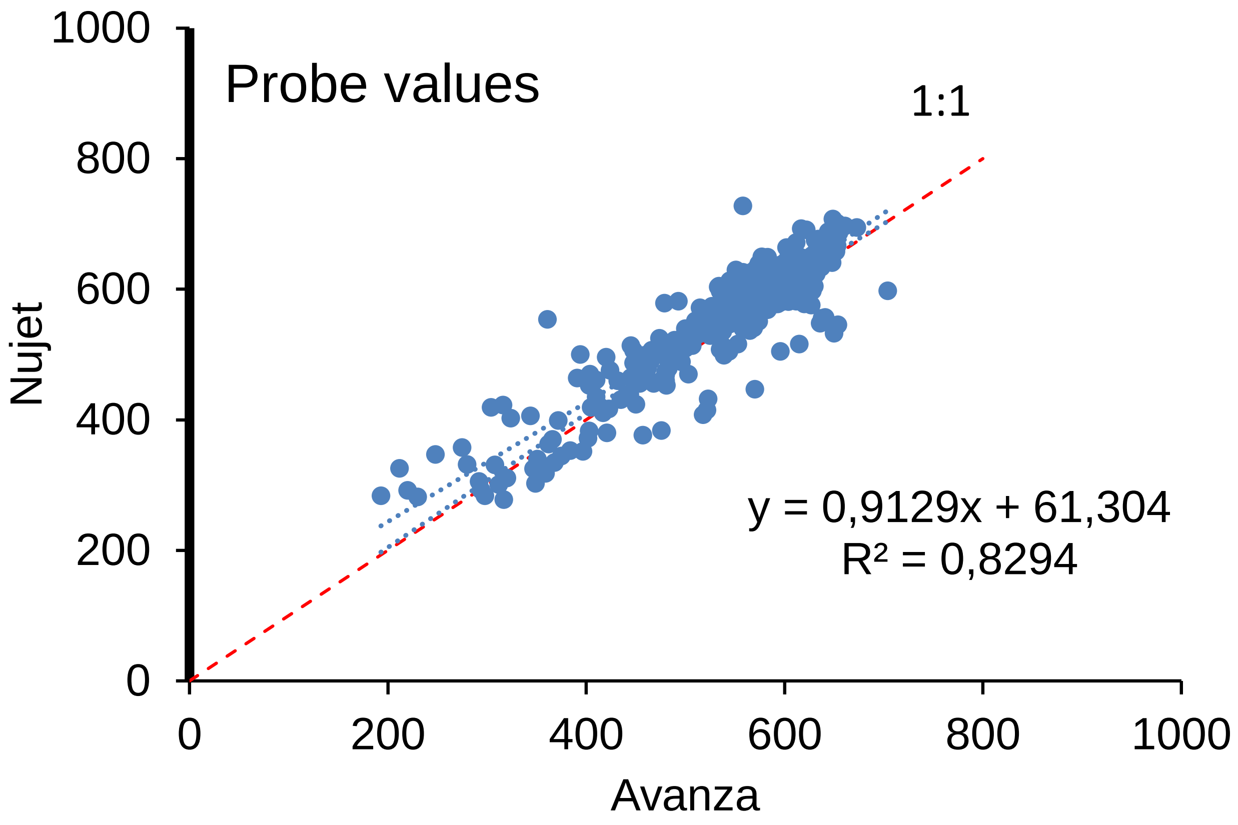
Upper and lowest limits of soil was measured and useful capacity at different depths were calculated

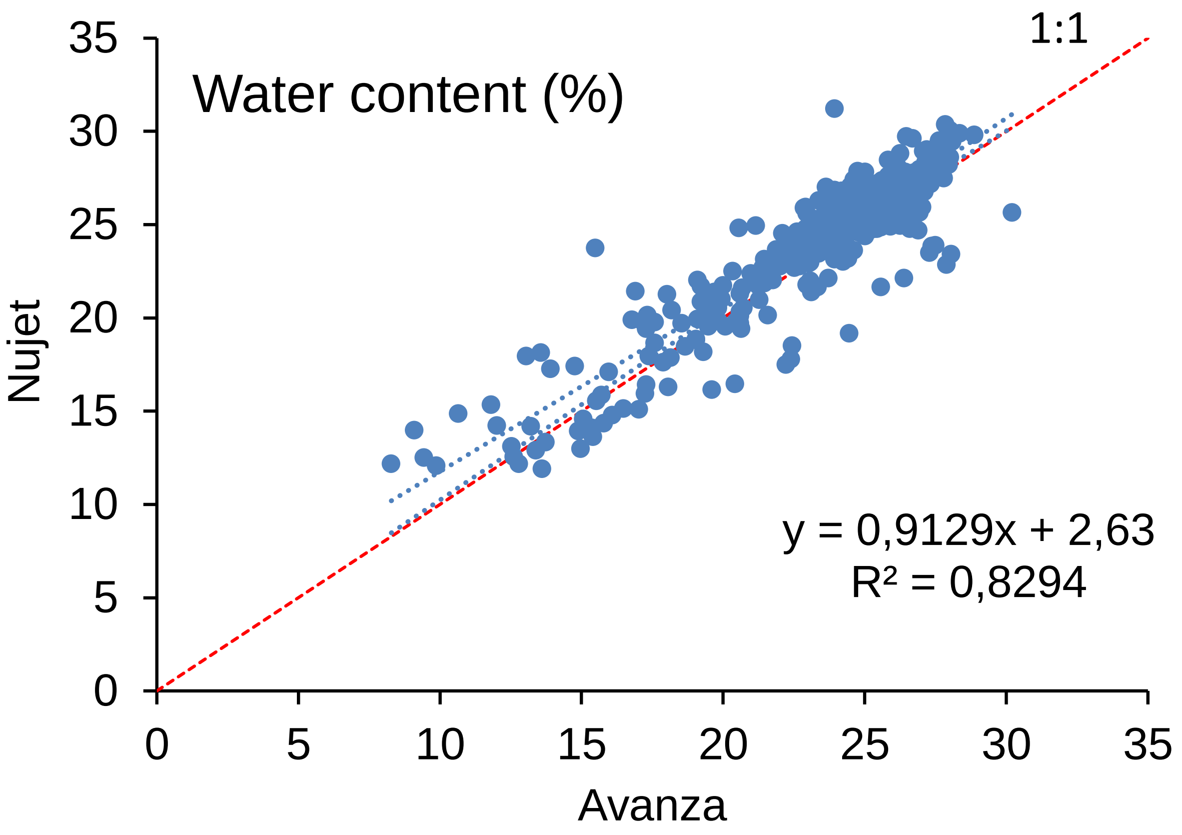






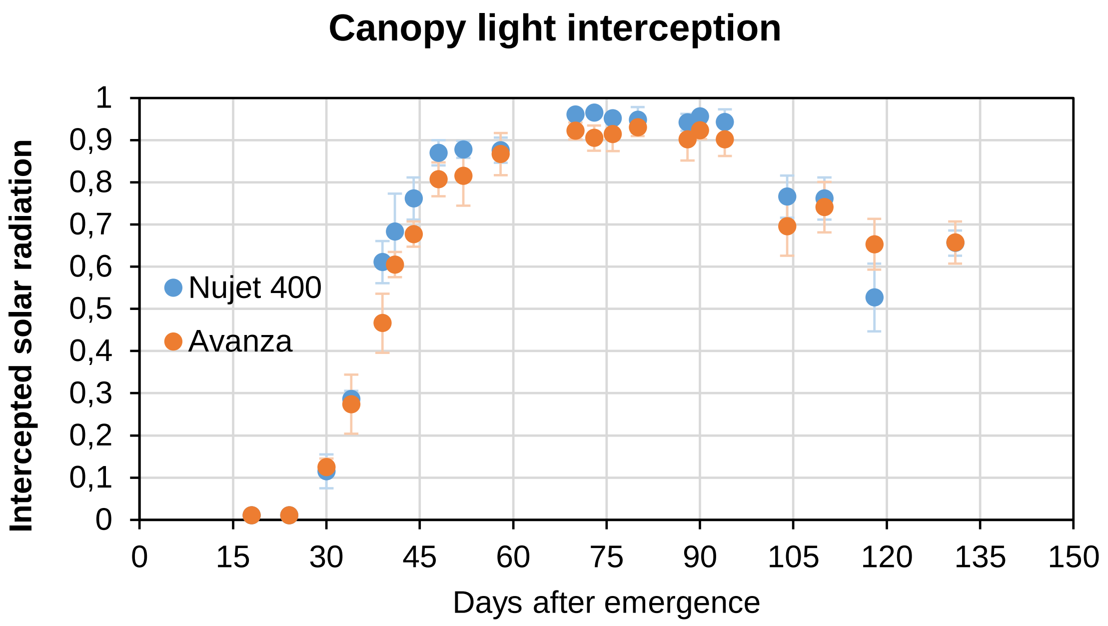
Soil water content: Probes and Water values throughout the crop cycle

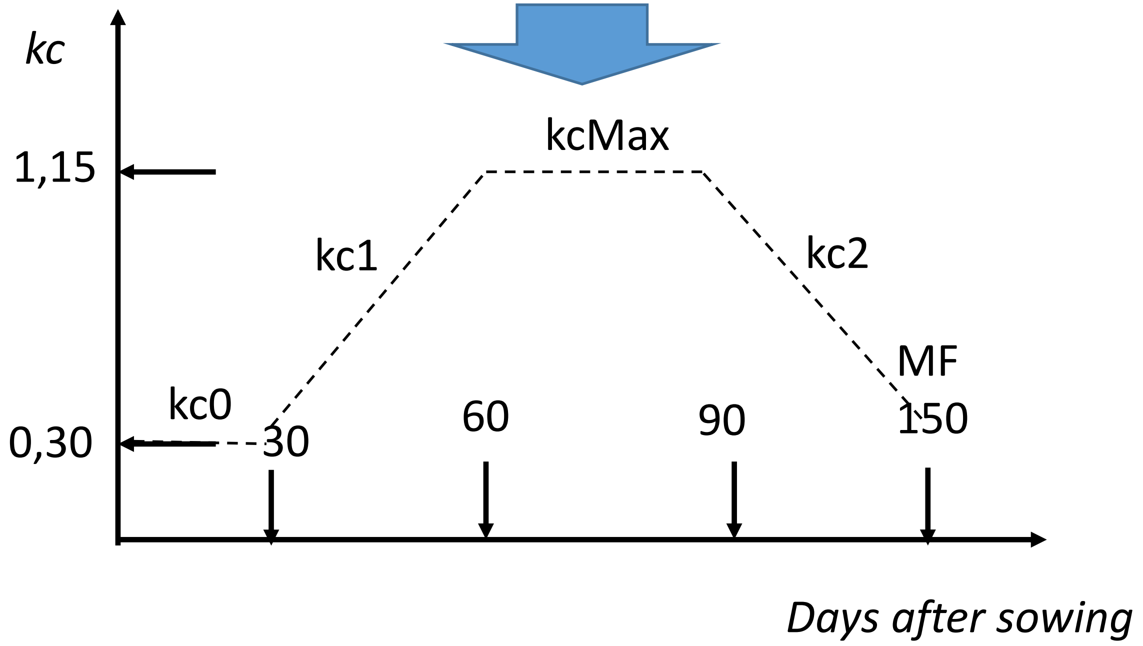




The comparison of probe values and % of water in the soil throughout the cycle between Avanza and Nujet did not show significant differences, although Nujet showed slightly higher values than Avanza. The slope of the regression 0,91 was similar than the 1:1 relationship.

Evapotranspiration (ETc) calculation 2021





The Kc coefficient was calculated taking account the dynamic of canopy light interception. Thus, the maximum value of Kc was 1,15 between 60 and 90 days after sowing and at physiological maturity the value was 0,30 (Andriani 2017 & FAO).

Equations:

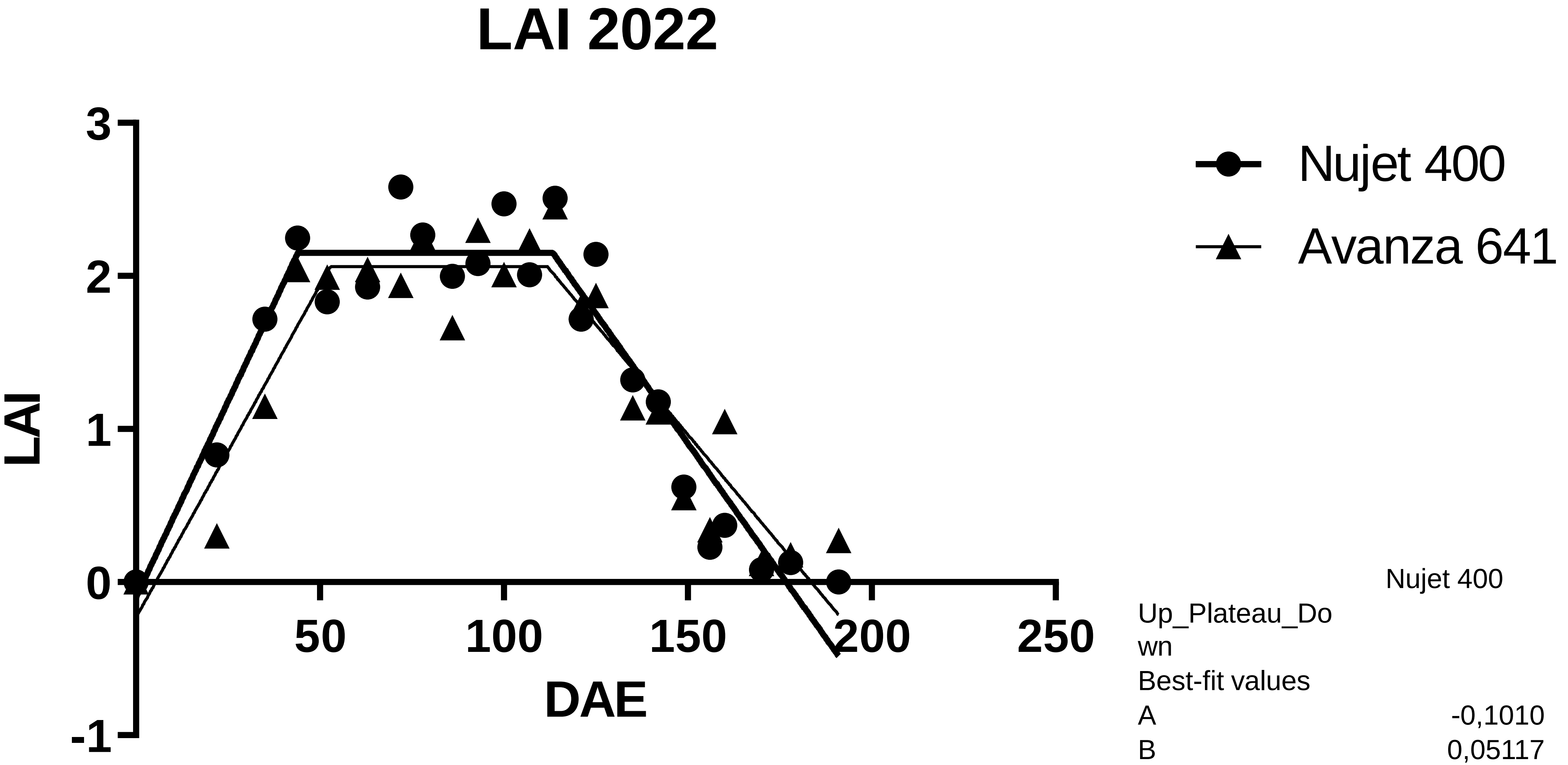
Kc0=0,3 (from sowing to 30 DAS)

Kc1: Y= 0,975+0,0425x (From 30 to 60 DAS)

Kc Max 1,15 (60-90 DAS)

Kc2: y= 2,425-0,0142x (From 90 to 150 DAS)

Evapotranspiration (ETc) calculation 2022

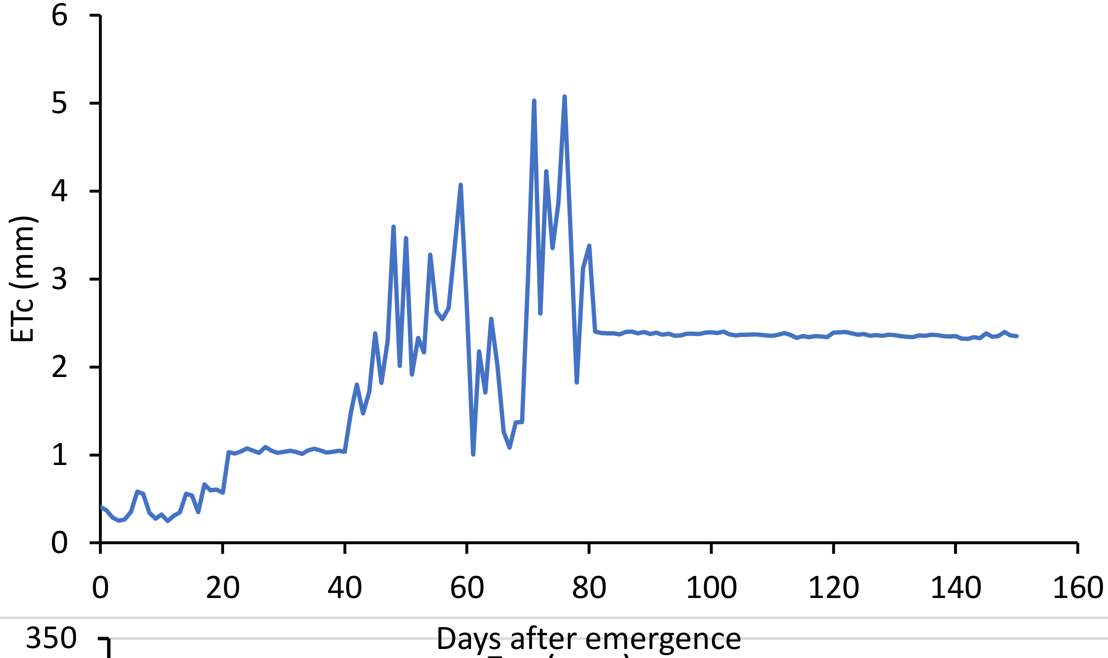


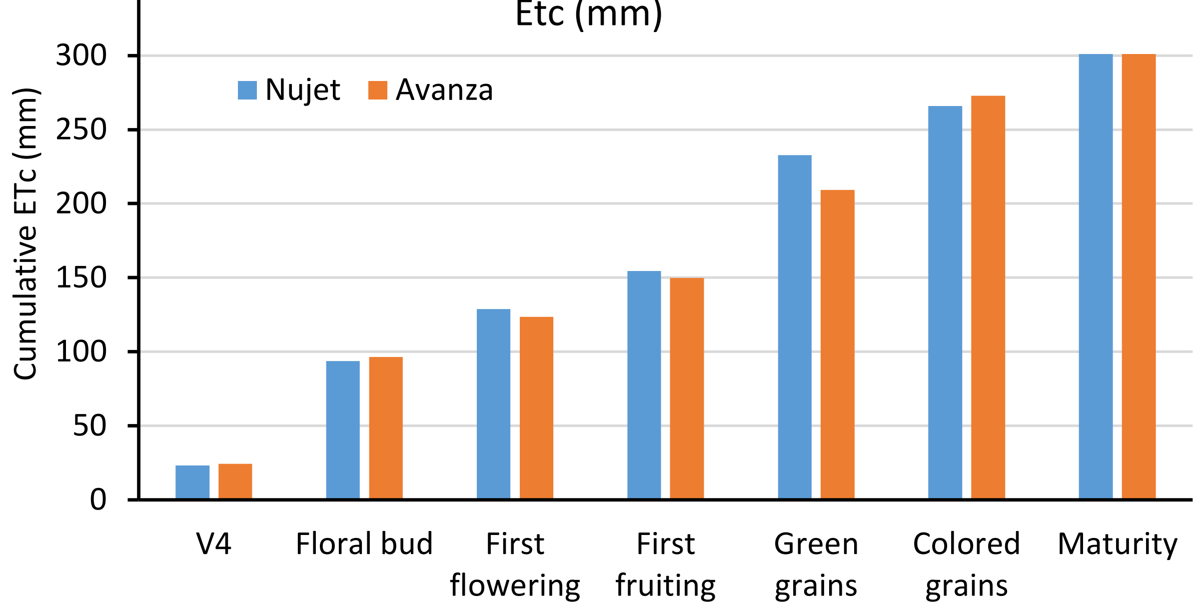
	Nujet 400	Avanza 641
Up_Plateau_Down		
Best-fit values		
A	-0,1010	-0,2329
B	0,05117	0,04343
C	44,00	52,83
E	-0,03389	-0,02874
D	113,4	111,9

Potential Evapotranspiration (Eto) according to the Penman FAO formulae

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

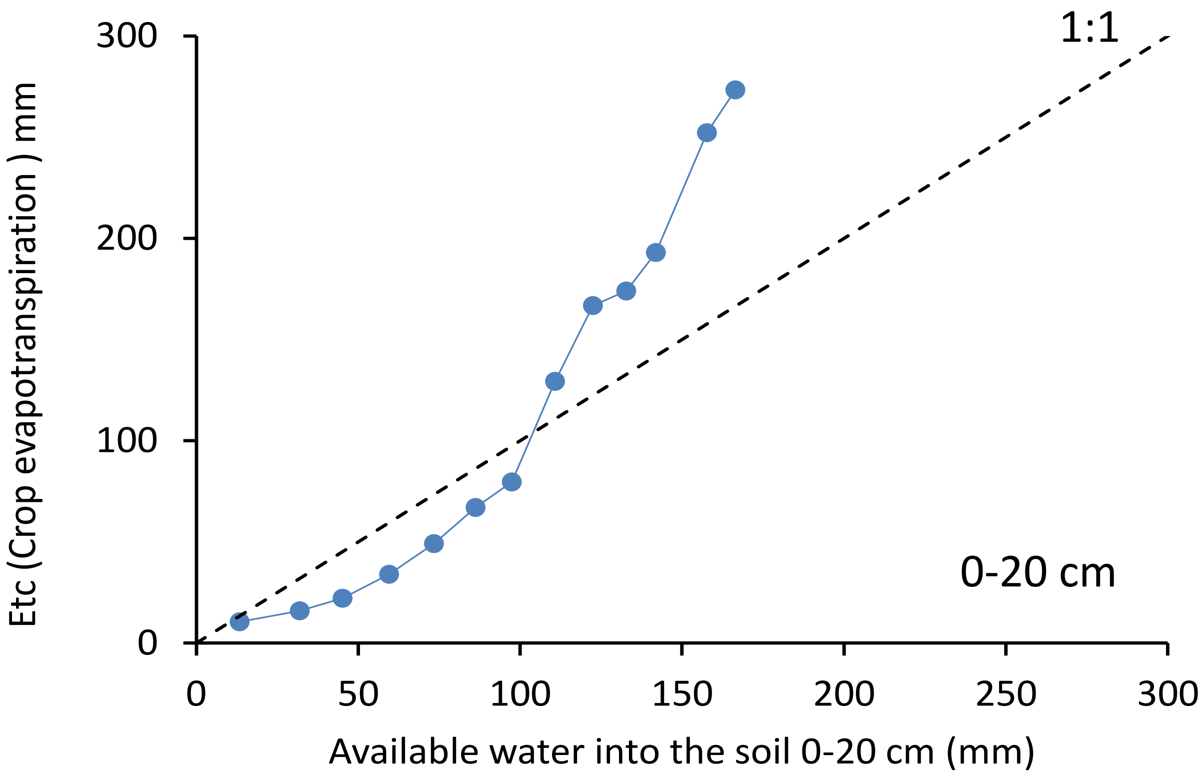
ET_o	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour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

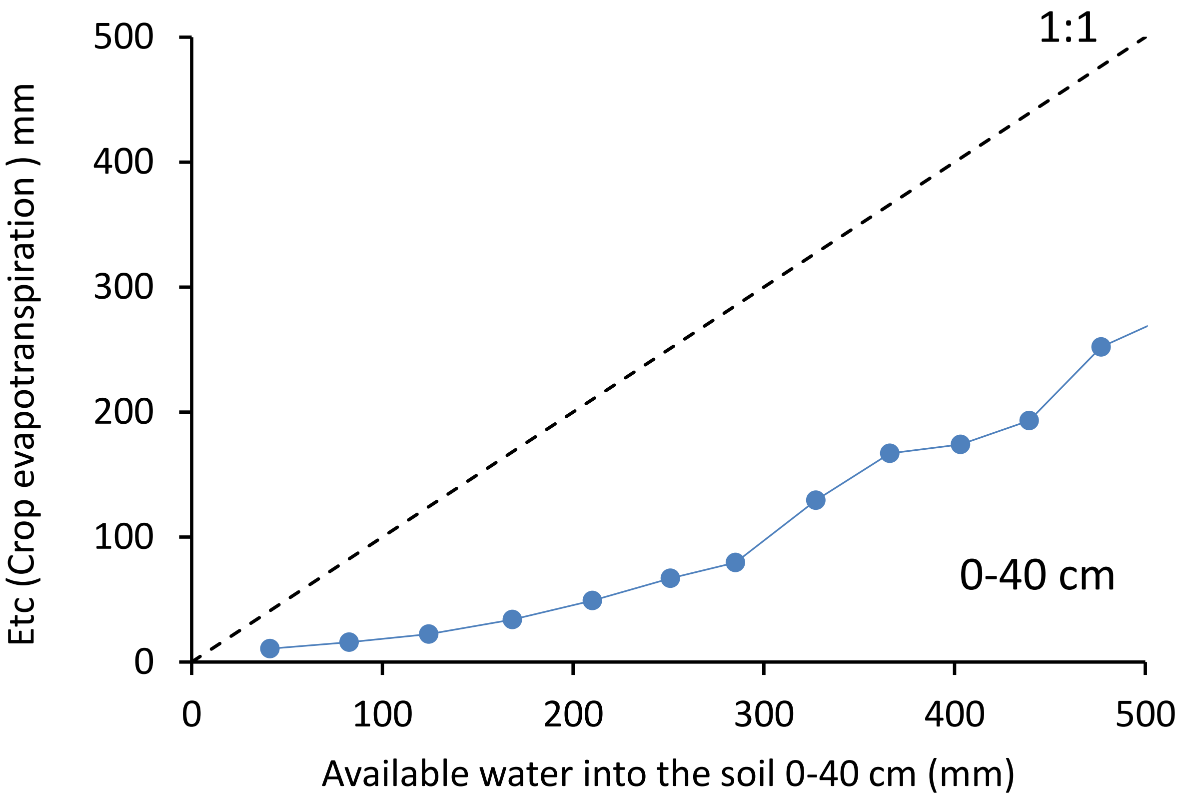




Crop demand measured by the evapotranspiration of the crop (ETc) was between 0.5 mm/day to 5 mm/day.

Crop Evapotranspiration (Etc) vs water availability in the soil

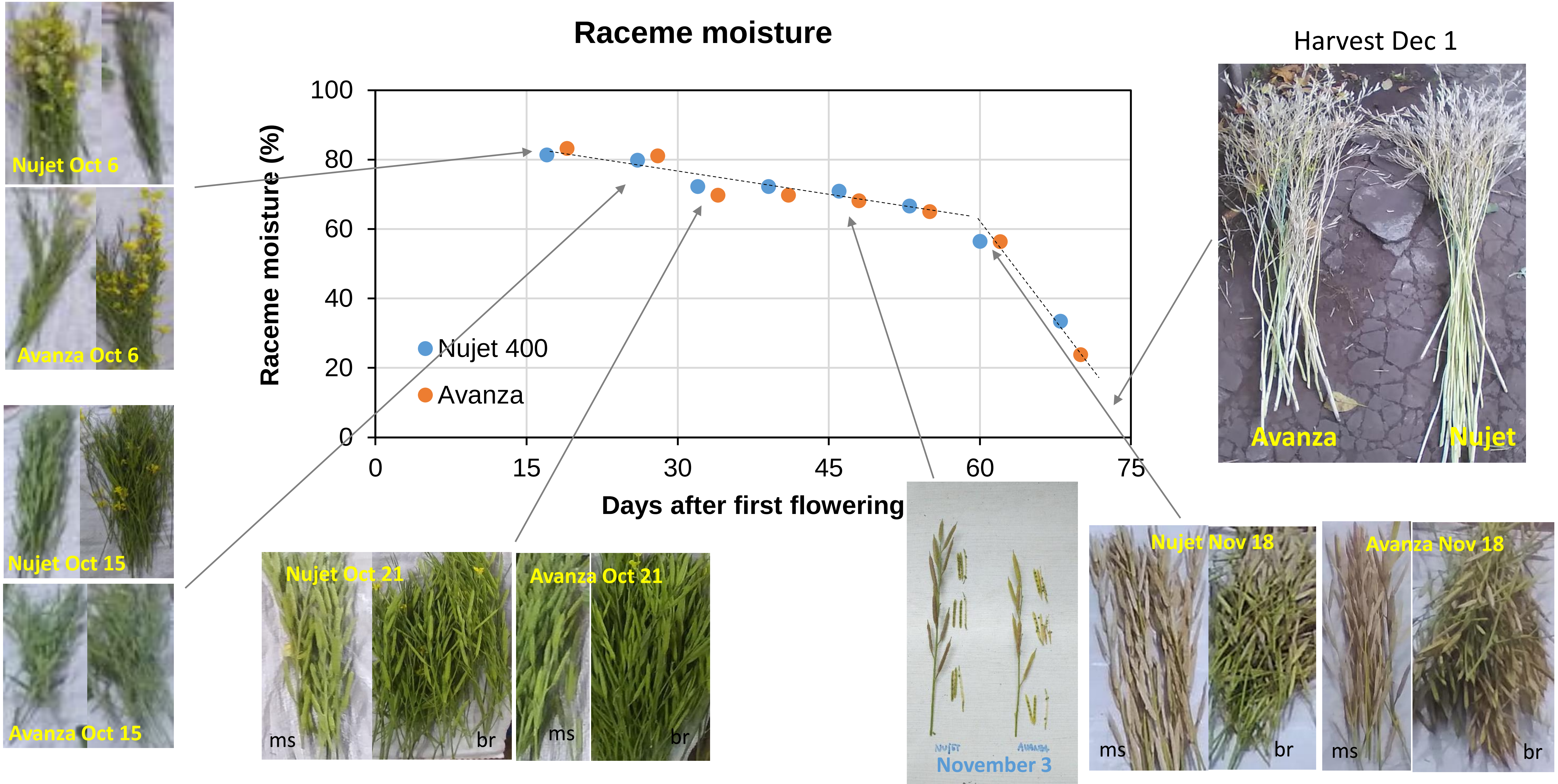




The comparison between ETc and available water into the soil showed that considering the soil depth from 0-20 cm water was enough during the first stages of the crop up to First Flowering but after that stage water availability in the first 20 cm was lower than the crop demand. However, when 0-40 cm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

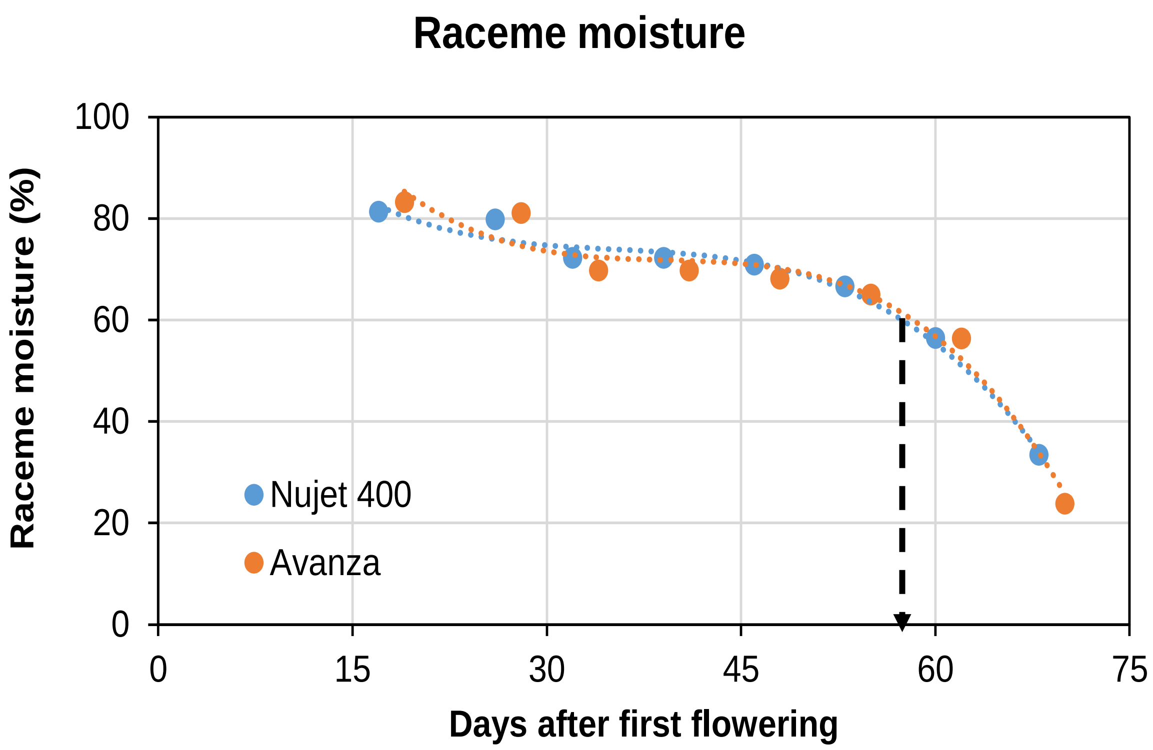
Harvest time and grain yield

Dynamics of raceme moisture

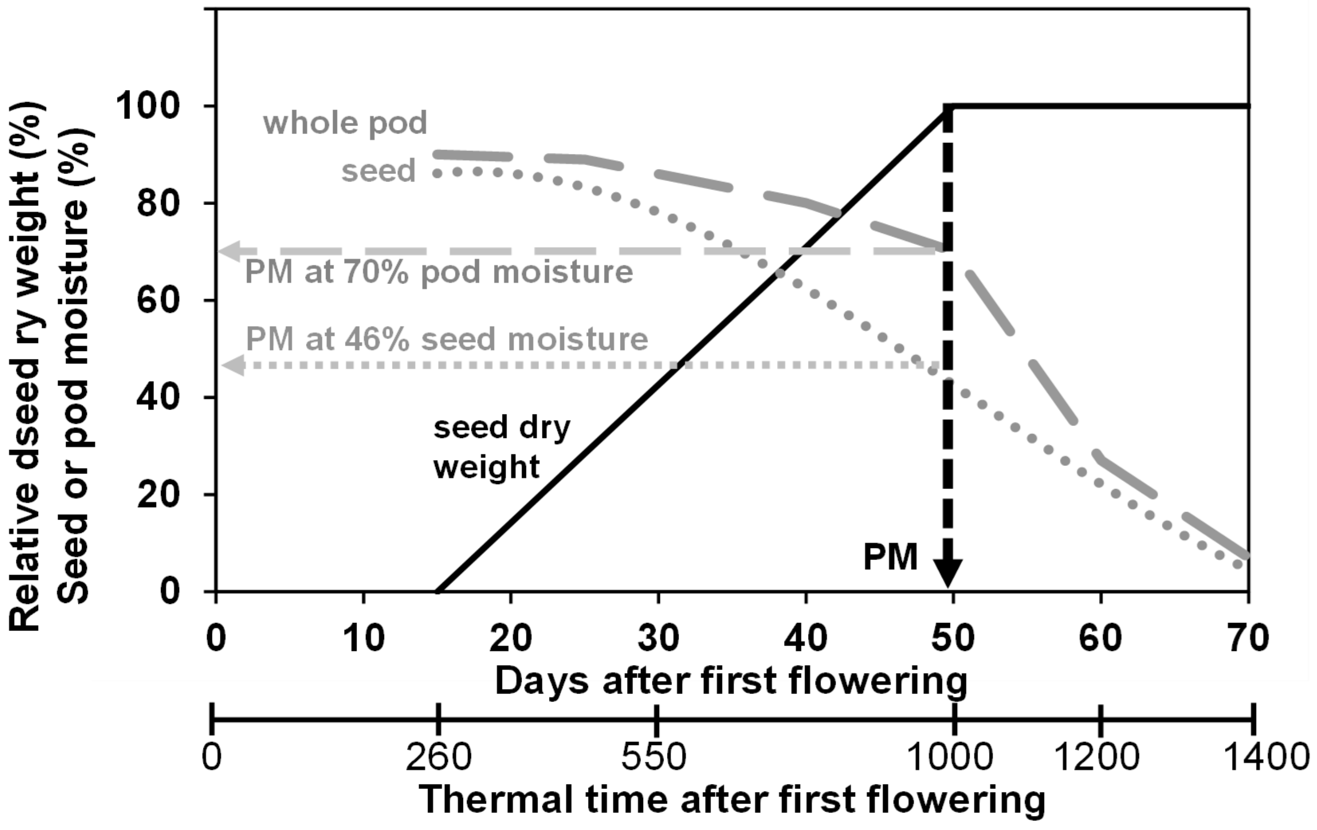


Dynamics of raceme moisture

-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 2021

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 higher in the canopy respect to Avanza 641.

Crop harvest 2022

November 11, 2022 (213 days after emergence; 219 days after sowing)

For each plot, 3 m (0.6 m^2) from central rows were hand-harvested from different areas in the plot (covering natural plot heterogeneity)

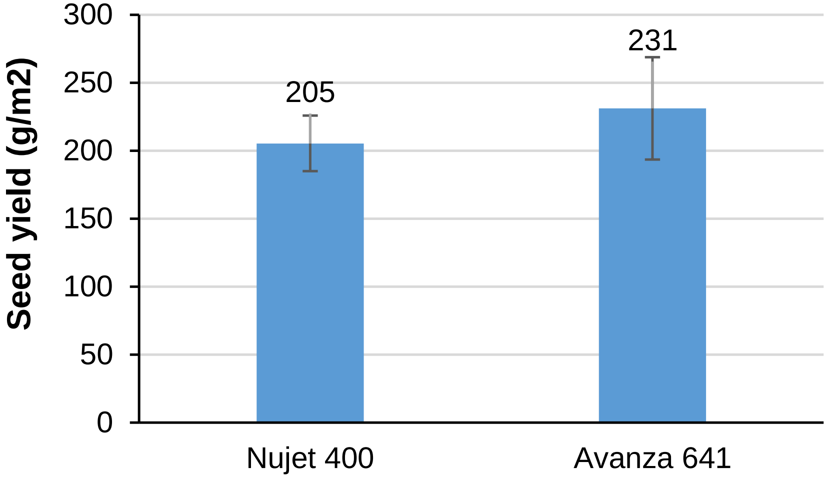
Canopy structure at harvest

Canopy structure	Nujet 400	Avanza 641	*p-value*
Plant height (cm)	**172 ± 5,7 a**	**147 ± 4,5 b**	**0,0083**
Main raceme length (cm)	32 ± 2,5	37 ± 0,8	0,1008
Height to the first basal siliques (cm)	**122 ± 4,8 a**	**98 ± 4,7 b**	**0,0073**
Number of primary branches (#/pl)	7,8 ± 0,7	6,8 ± 0,4	0,2903
Number of siliques from the main raceme (#/pl)	**19 ± 1,0 a**	**17 ± 0,3 b**	**0,0316**

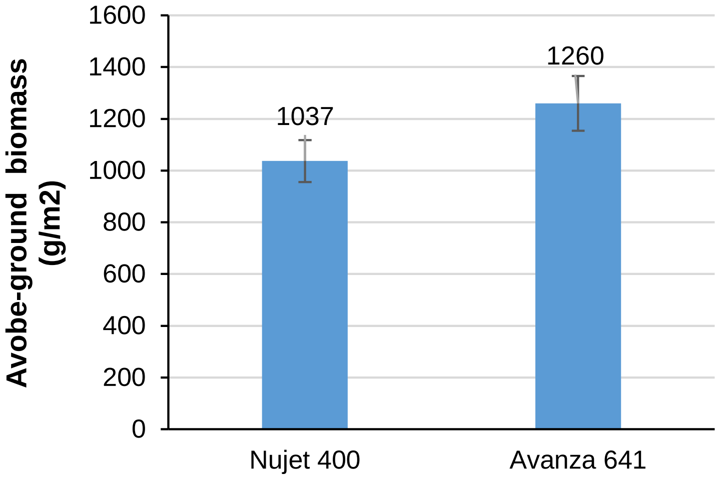
Nujet 400 had plants 25 cm taller, with significantly more siliques on the main raceme, and the first basal siliques were located taller in the canopy respect to Avanza 641. Despite the height, they did not lodge
Unlike 2021, branching did not differ significantly between genotypes.
In both, 2021 and 2022, the silique layer expanded by about 40-50 cm.

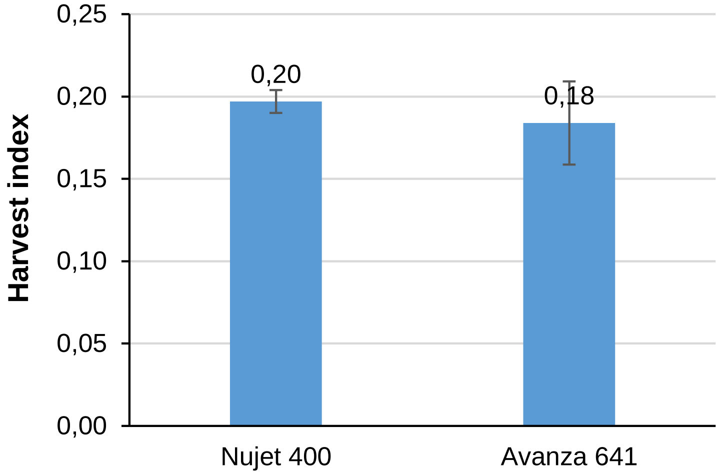
Seed yield and its components 2022

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

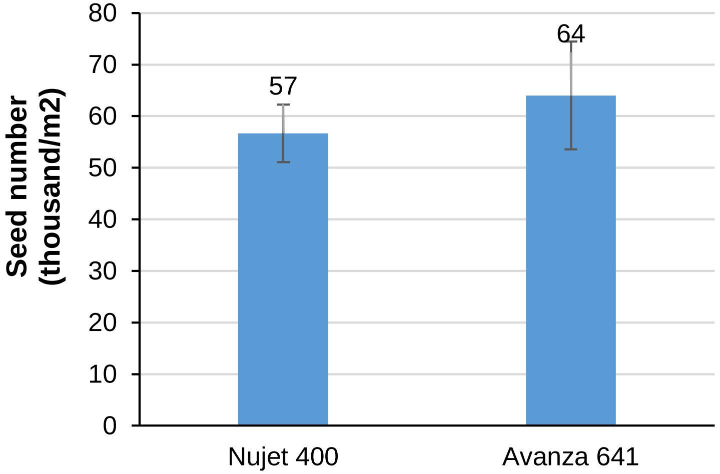


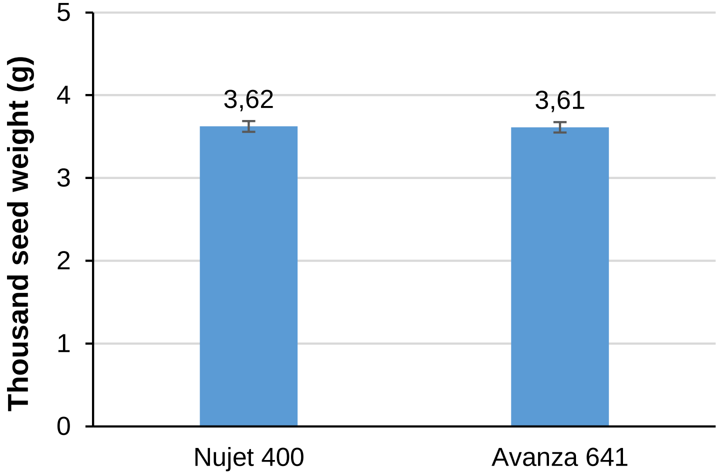
B carinata 2022





2000-2300 kg seed/ha (DW)
Similar in both genotypes
High variability, especially for Avanza





Seed yield did not exceed that of 2021 (2200-2300 kg/ha) despite having 40 more days of cycle
Harvest index was lower (0.18-0.20) than in 2021 (0.24) and USA (0.28-0.37) and Uruguay (0.23-0.34) Seepaul et al. (2021); Mazzilli & Ernst (2020). Flowering at late July-early August doesn't seem suitable for high productivity in Buenos Aires

Freezing tolerance in different genotypes of Brassica Carinata: Experiments 2022

OBJECTIVE: Determine the freezing tolerance in 40 carinata genotypes.

Sowing date 1: 18 August 2022.

Sowing date 2: 5 September 2022.

Sowing date 3: 3 October 2022.

Sustrate: Mixture of peat, soil, compost and perlite (HI-SOIL; PH=6.5, E.C.=0.2 DM/cm, MO=21.6%, Ashes=78.4%, Density=446 g/cm3, Porosity=80.4%).

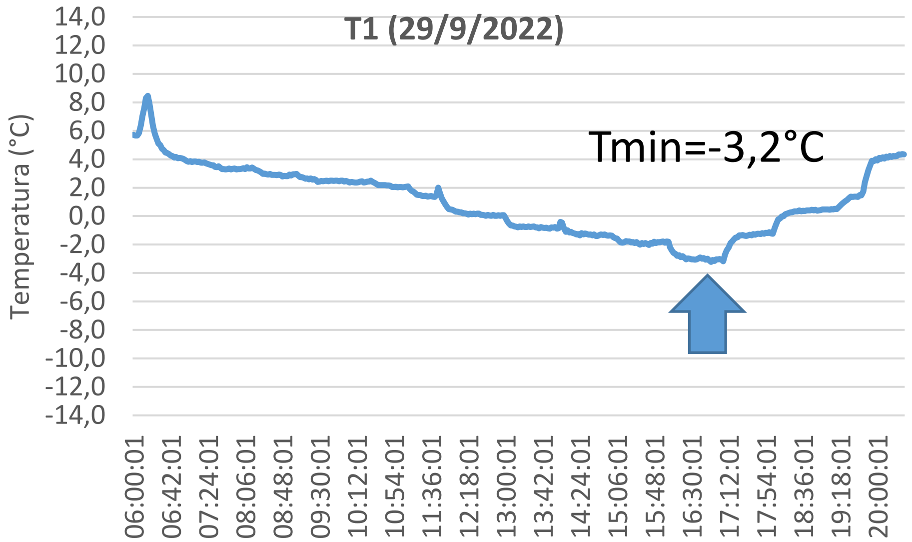
Plants Acclimation

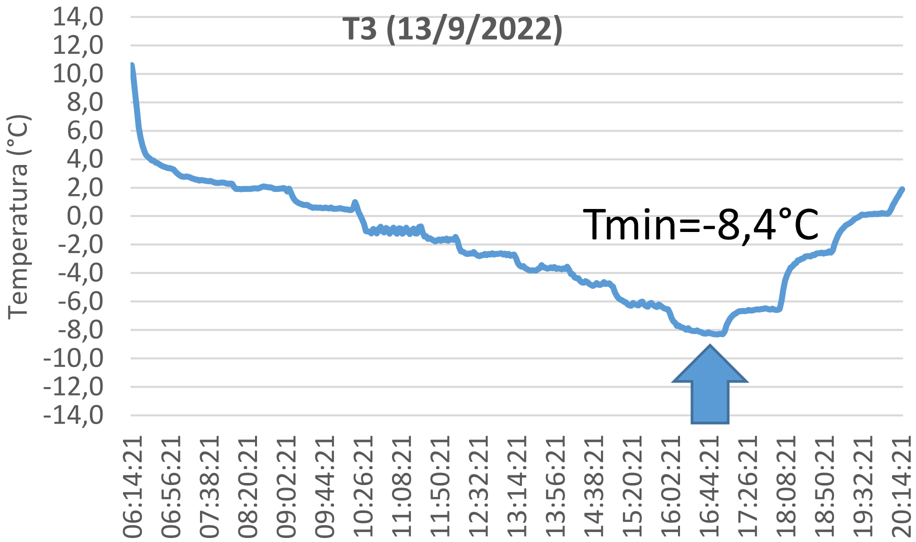
2 weeks at aprox 5-7 °C (10 hs photoperiod) in growth chamber (Fielbelkorn y Rahman, 2016)

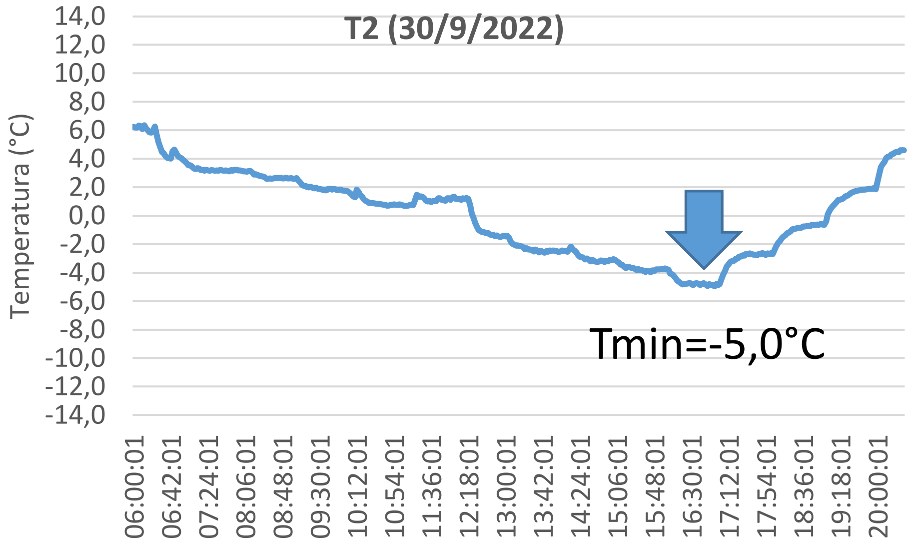
Freezing treatments

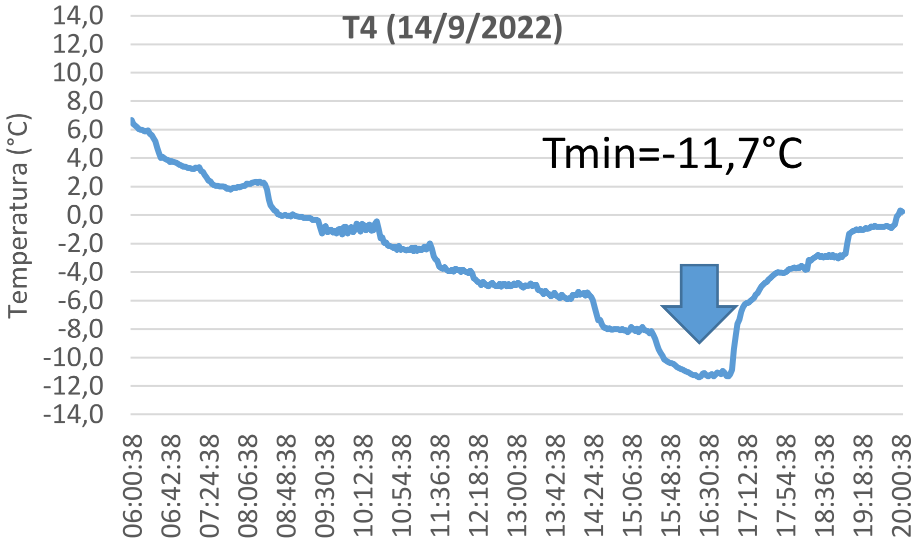
5 treatments simulating the dinamic of natural frost event during the night

Blue rows indicate the minimum temperature reached in each treatment.

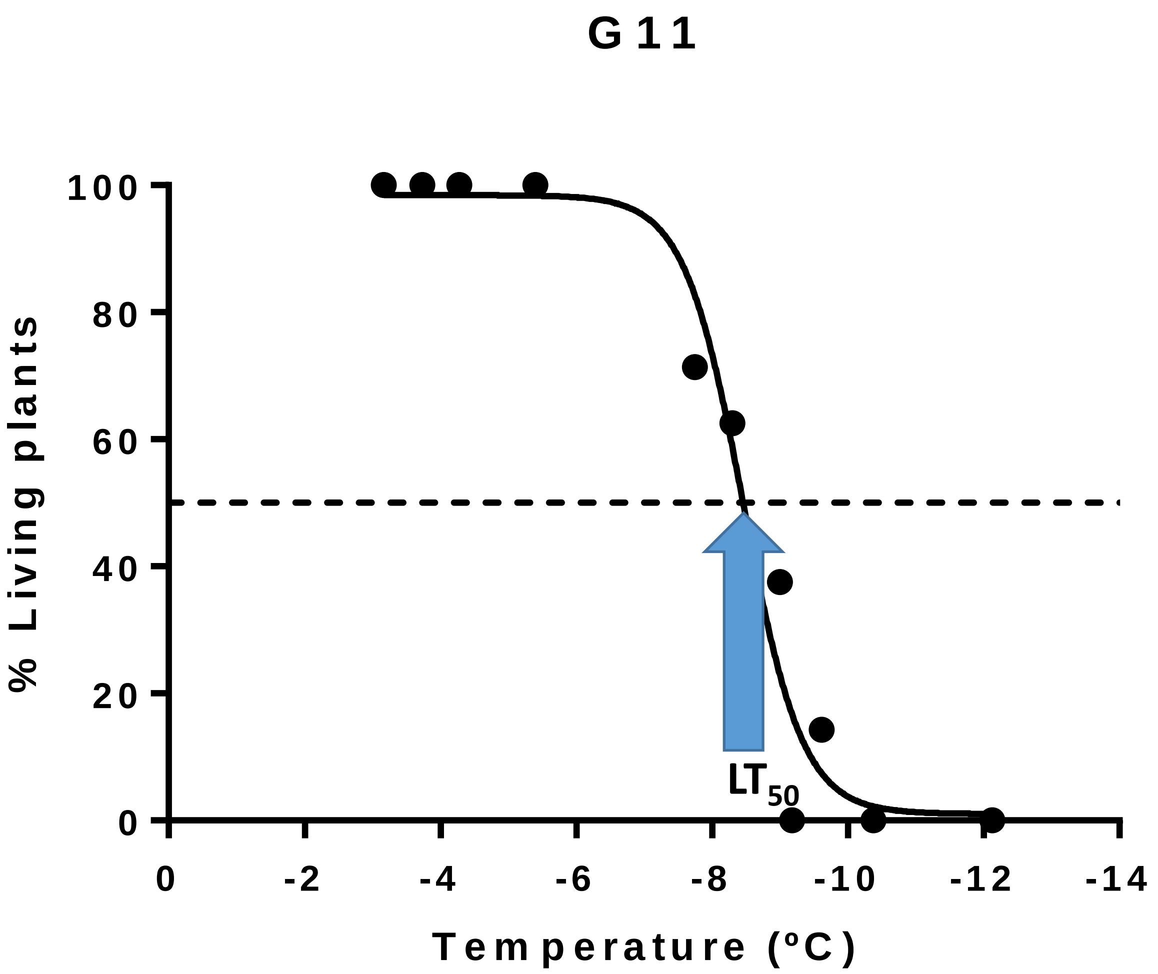


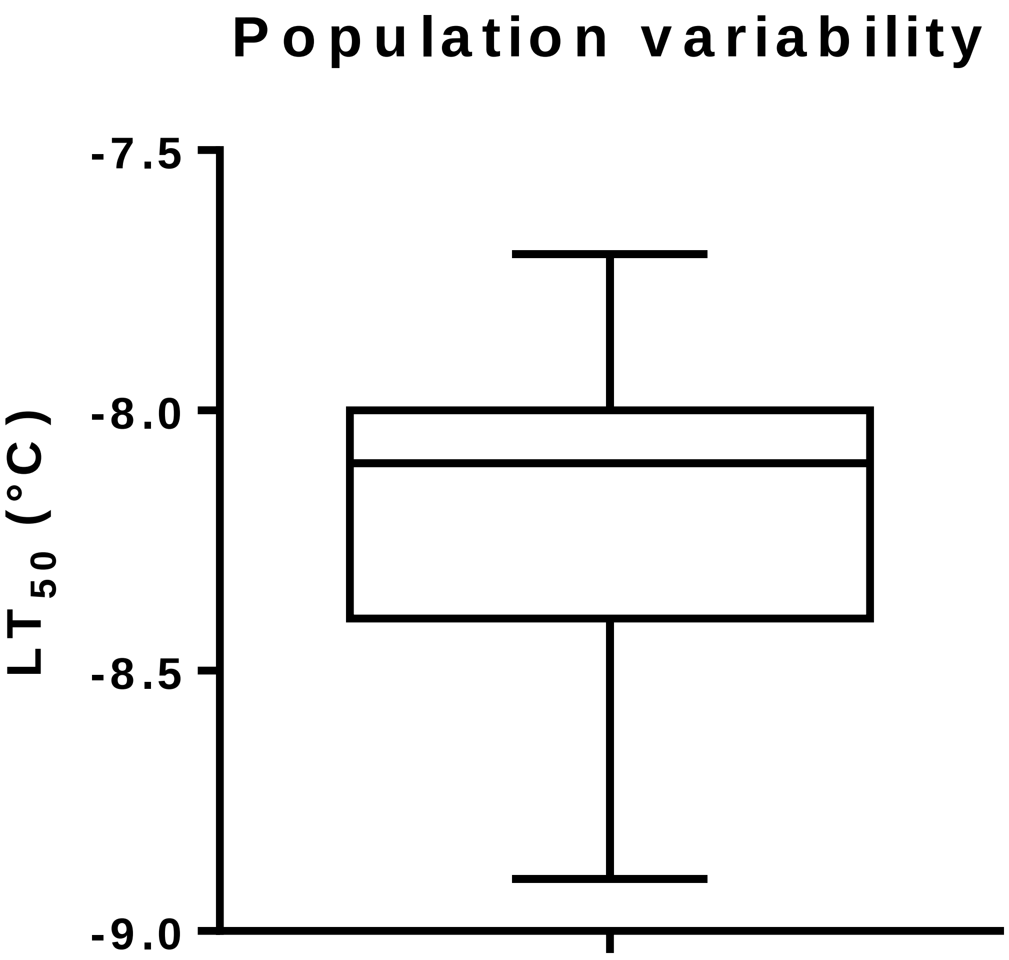






RESULTS: % Living plants





EXPERIMENT 2

Sowing date 4: 18 November 2022.

Sowing date 5: 3 January 2023.

Freezing treatments:

2 treatments (T1=-4.4°C and T2=-7.1°C) during 2 hs.

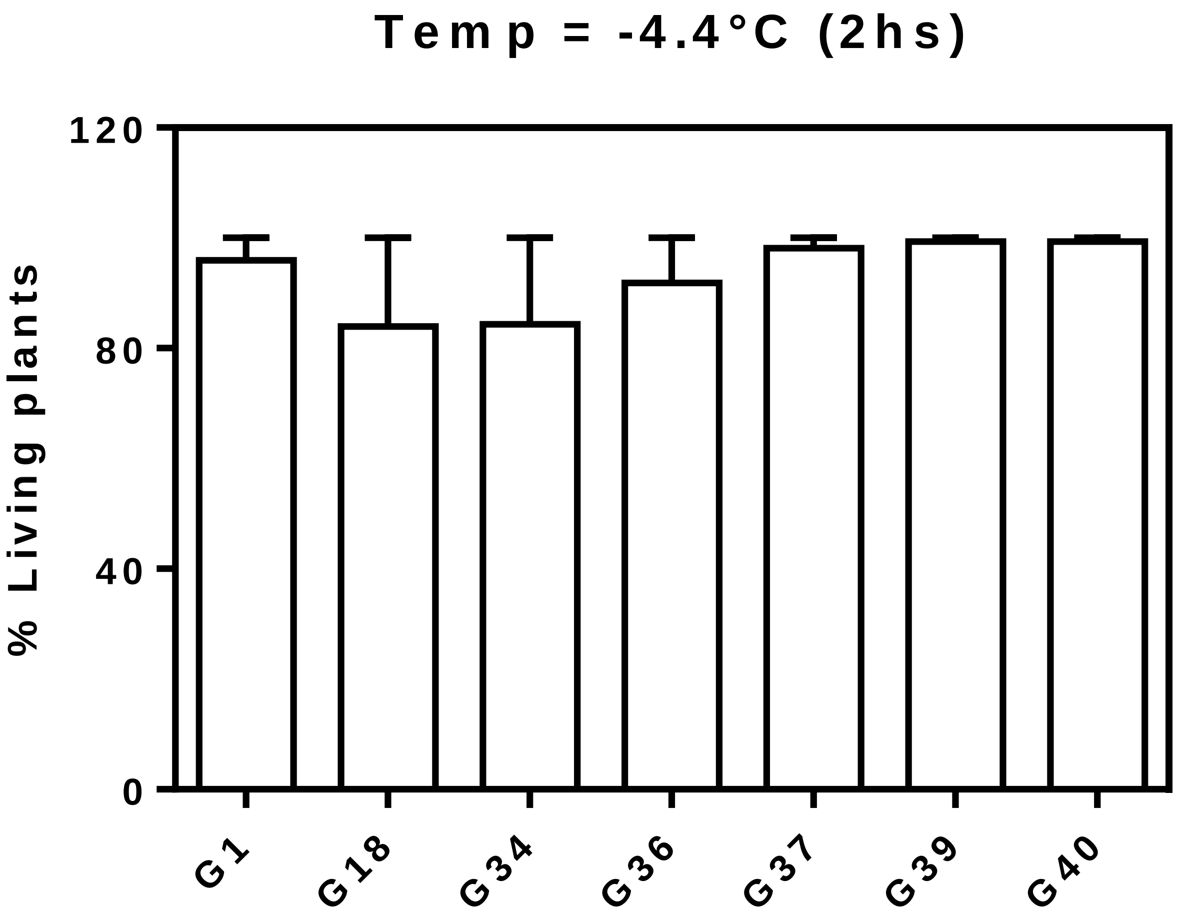
Results:

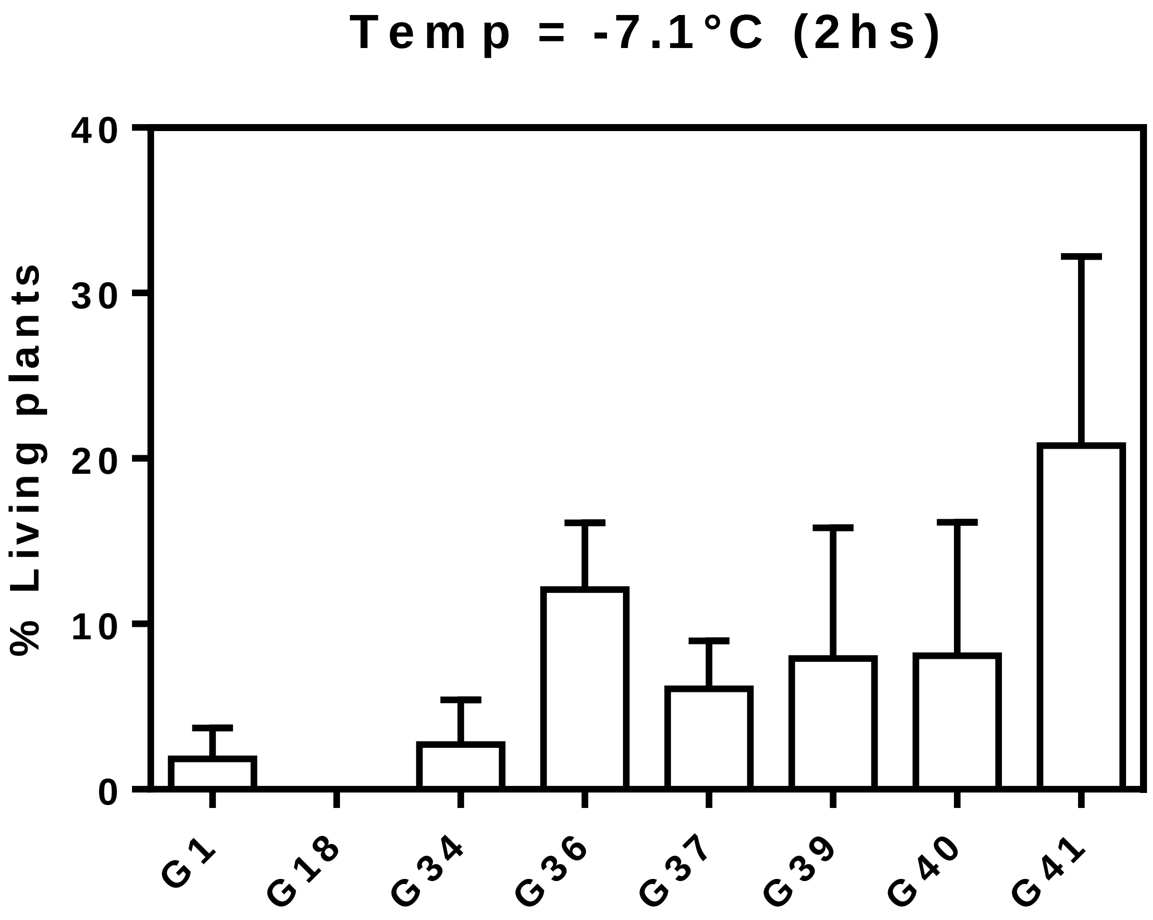
1) % Living plant.
2) Damage scale (Cativelli 2014)

Damage scale described by Cativelli (2014)

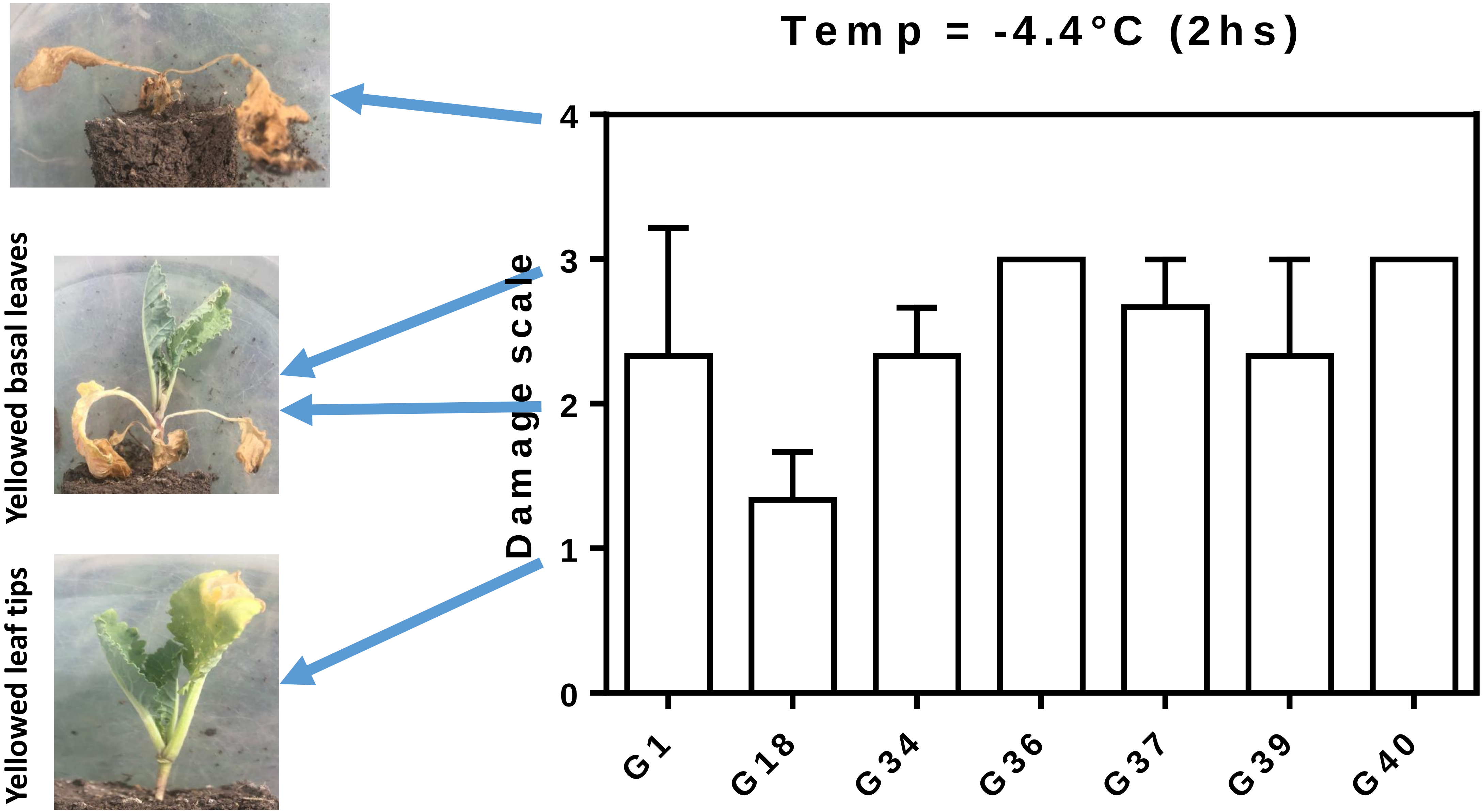
0: no damage
1: slightly yellowed leaf tips
2: half-yellowed basal leaves
3: fully yellowed basal leaves
4: whole plants slightly yellowed
5: whole plants yellowed and some plants withered
6: whole plants yellowed and 10 % plant mortality
7: whole plants yellowed and 20 % plant mortality
8: whole plants yellowed and 50 % plant mortality
9: all plants killed

RESULTS: % LIVING PLANTS





RESULTS: DAMAGE SCALE (CATIVELLI, 2014)



CONCLUSIONS

- Temperatures between 0°C and approx. -5°C (Tmin) did not affect the plants survival in any genotypes.
- However, the damage observed in leaves (according to Cativelli, 2014) at this temperature was different among genotypes.
- Temperatures below -5°C (Tmin) showed slightly genotypic variability in plant survival (LT_{50}).

Experiments 2023

Experiments 2023

Experiment 1- Phenology: Include a wide range of sowing dates (seven) for complementing the data obtained in 2022 for the hybrid NUJET 350 (including 2 other experimental genotypes Exp087 and Exp095)
Sowing dates from April to August recording different phenological stages according to CETIOM scale.

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

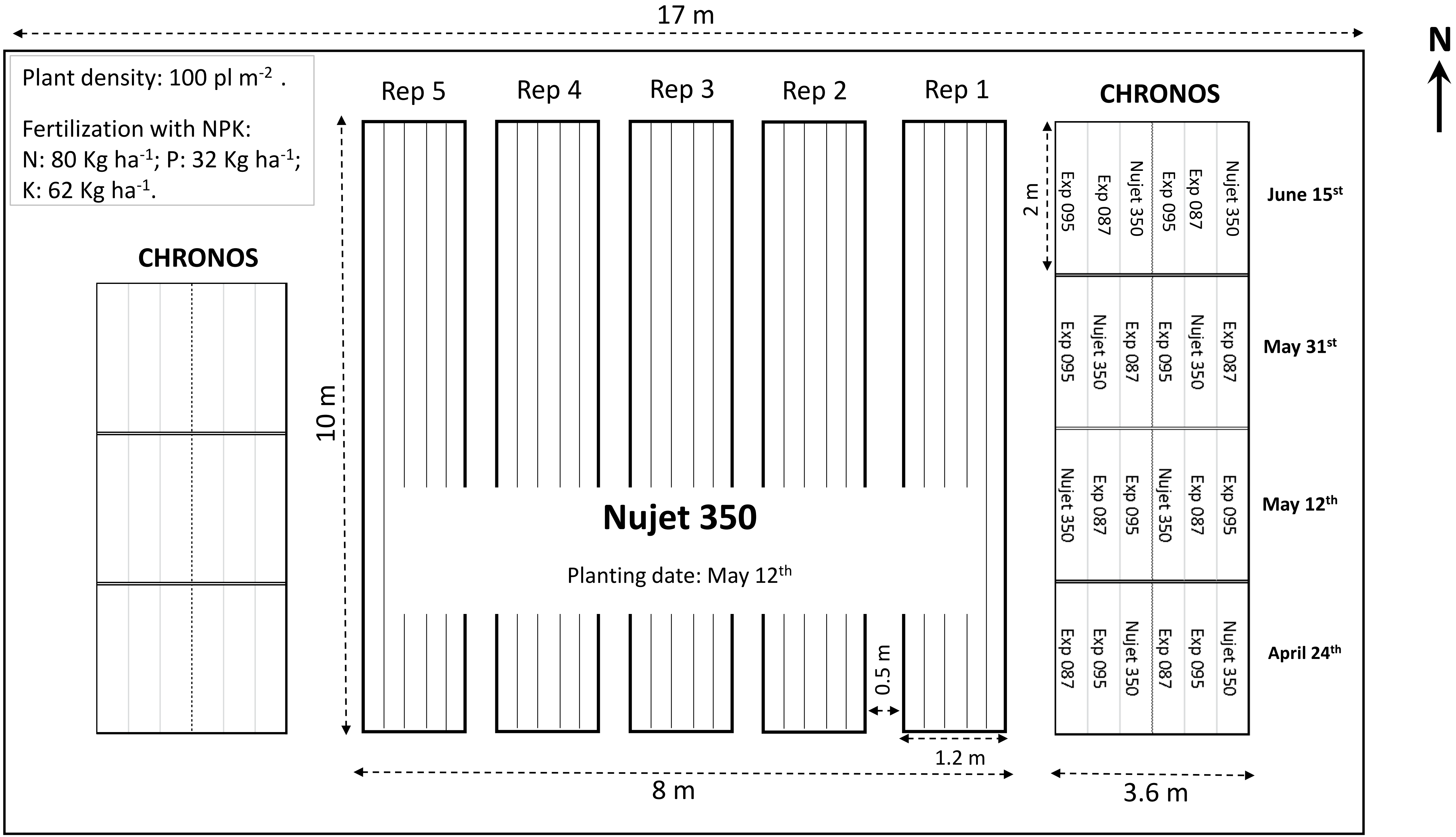
Seven sowing dates: At the moment April 24, May 12, May 31, June 15

Experiment 2- Biomass and yield construction for the hybrid NUJET 350.

OBJECTIVES:

1) Characterize the biomass production dynamics (carbon and nitrogen), both aerial and root, throughout the crop cycle and yield and its components, in the Nujet 350 genotype of Brassica carinata A.Braun;
2) Analyse changes in the biomass partition between the aerial and root part.

This experiment was sown in the experimental field of the FAUBA on May 12 2023 at 100 pl/m^2, with 5 reps in plots of 6 rows x 10 m long. See details in the map plot (next slide)


17 m
N
Plant density: 100 pl m-2 .
Fertilization with NPK:
N: 80 Kg ha-1; P: 32 Kg ha-1;
K: 62 Kg ha-1.
Rep 5
Rep 4
Rep 3
Rep 2
Rep 1
CHRONOS
CHRONOS
10 m
2 m
Exp 095
Exp 087
Nujet 350
Exp 095
Exp 087
Nujet 350
June 15st
Exp 095
Nujet 350
Exp 087
Exp 095
Nujet 350
Exp 087
May 31st
Nujet 350
Exp 087
Exp 095
Nujet 350
Exp 087
Exp 095
May 12th
Exp 087
Exp 095
Nujet 350
Exp 087
Exp 095
Nujet 350
April 24th
Nujet 350
Planting date: May 12th
0.5 m
1.2 m
8 m
3.6 m

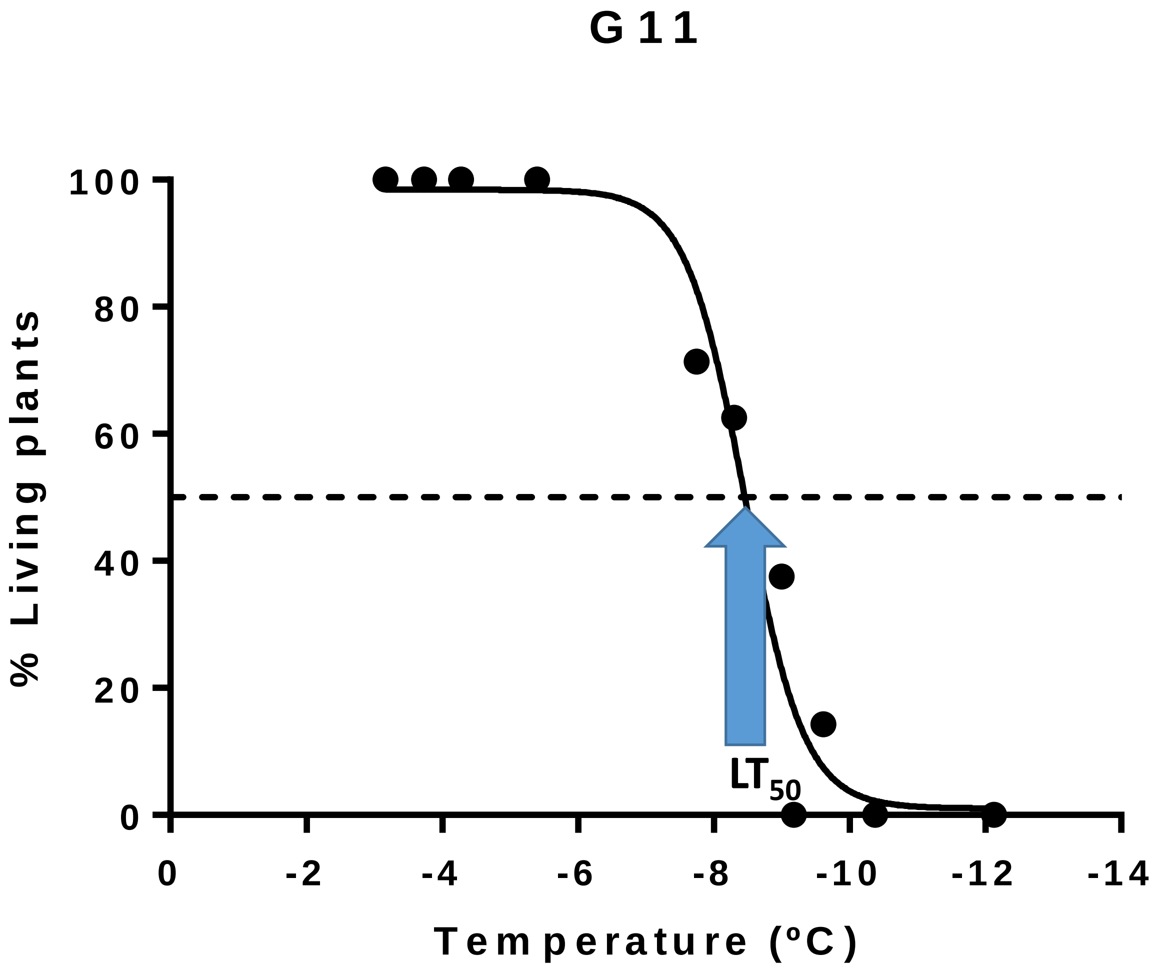
Experiment 3: Tolerance in different genotypes of Brassica Carinata

OBJECTIVE: Determine the freezing tolerance in 15 carinata genotypes.

Sowing date: July/August 2023

Sustrate: Mixture of peat, soil, compost and perlite (HI-SOIL; PH=6.5, E.C.=0.2 DM/cm, MO=21.6%, Ashes=78.4%, Density=446 g/cm3, Porosity=80.4%).

Aclimatation: 2 weeks at aprox 5-7 °C (10 hs photoperiod) in growth chamber (Fielbelkorn y Rahman, 2016). FREEZING TEMPERATURES: (i) 0 ºC, (ii) -5 ºC (iii) -7 ºC (iv) -9 ºC y (v) -12 ºC.



Damage scale described by Cativelli (2014)

0: no damage

1: slightly yellowed leaf tips

2: half-yellowed basal leaves

3: fully yellowed basal leaves

4: whole plants slightly yellowed

5: whole plants yellowed and some plants withered

6: whole plants yellowed and 10 % plant mortality

7: whole plants yellowed and 20 % plant mortality

8: whole plants yellowed and 50 % plant mortality

9: all plants killed

Experiment 4: Long-term Carinata Plant/Soil Controlled Study.

Overview

Carinata is a cash crop that could fulfill functions that would make it an excellent cover crop due to its effects on hydrophysics properies:

- soil porosity
- agregate stability
- movement and water storage

and soil organic carbon storage.

Experimental set up

- Venado Tuerto (Santa Fe) NUSEED
- Long term experiment (3-5 years)
- 3 rotations: Carinata /Soybean 2, Wheat/Soybean 2 and Fallow/Soybean 1

240 m (80 m each)

Carinata/Soybeana REP 1	Carinata/Soybean REP 2	Carinata/Soybean REP 3
Wheat/Soybean REP 1	Wheat/Soybean REP 2	Wheat/Soybean REP 3
fallow/Soybean REP 1	fallow/Soybean REP 2	fallow/Soybean REP 3

Experiment 4: Long-term Carinata Plant/Soil Controlled Study.

Measurements

- **Plant**
  - Yield of all crops
  - Aerial biomass at flowering and harvest and harvest index of all crops.
  - Water use efficiency for total biomass and yield.
  - Crop Nitrogen uptake and physiological and agronomic nitrogen recovery efficiencies.
  - Determination of N in flowering and harvest tissues (Kjeldahl).

- **Soil**
  - Initial basic soil properties: texture, pH, electrical conductivity, total carbon, extractable P, CEC and exchangeable cations, nitrates and sulphates.
  - Soil Water Properties: Field Capacity and Permanent Wiling poit, USDA Ring Infiltration, Aggregate stability, Bulk and Particle Density, Total Porosity. Initial (at sowing) and final (at harvest) water content of each of the crops.
  - Soil sampling will be done with an auger taking a composed sample of 10 pits per plot in order to take only 1 representative sample (at each depth) of each plot.
  - Aggregate stability, field capacity and permanent wilting point will be sampled with a shovel so as not to disturb the physical properties, taking 3 pikes per plot.

Experiment 4 : Venado Tuerto 2023 (20/7/2023)

Venado Tuerto 2023
(20/7/2023)

Venado Tuerto 2023 (20/7/2023)

Venado Tuerto 2023
(20/7/2023)

Thanks for inspiring and supporting this work

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