Long-term Rotations experiment in Venado Tuerto, Argentina. Report 2024

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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.

Carinata, july 2023

Experimental set up June 2023

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

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

240 m (80 m each)

Sampling campaigns (2024)

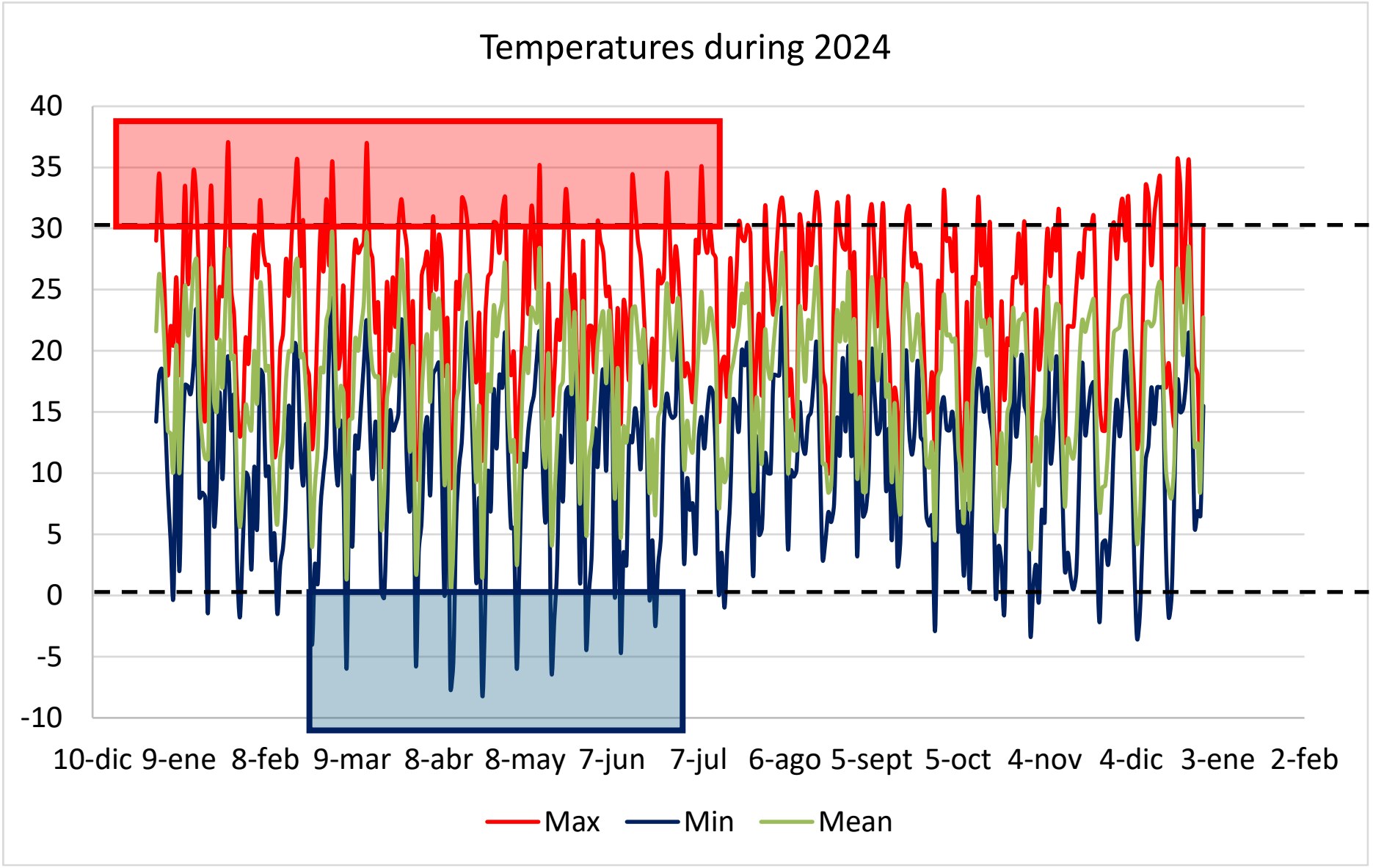
- 1- Soybean 1 harvesting (04/2024)

- 2- Soybean 2 harvesting (05/2024)

Sampling campaigns (2024)

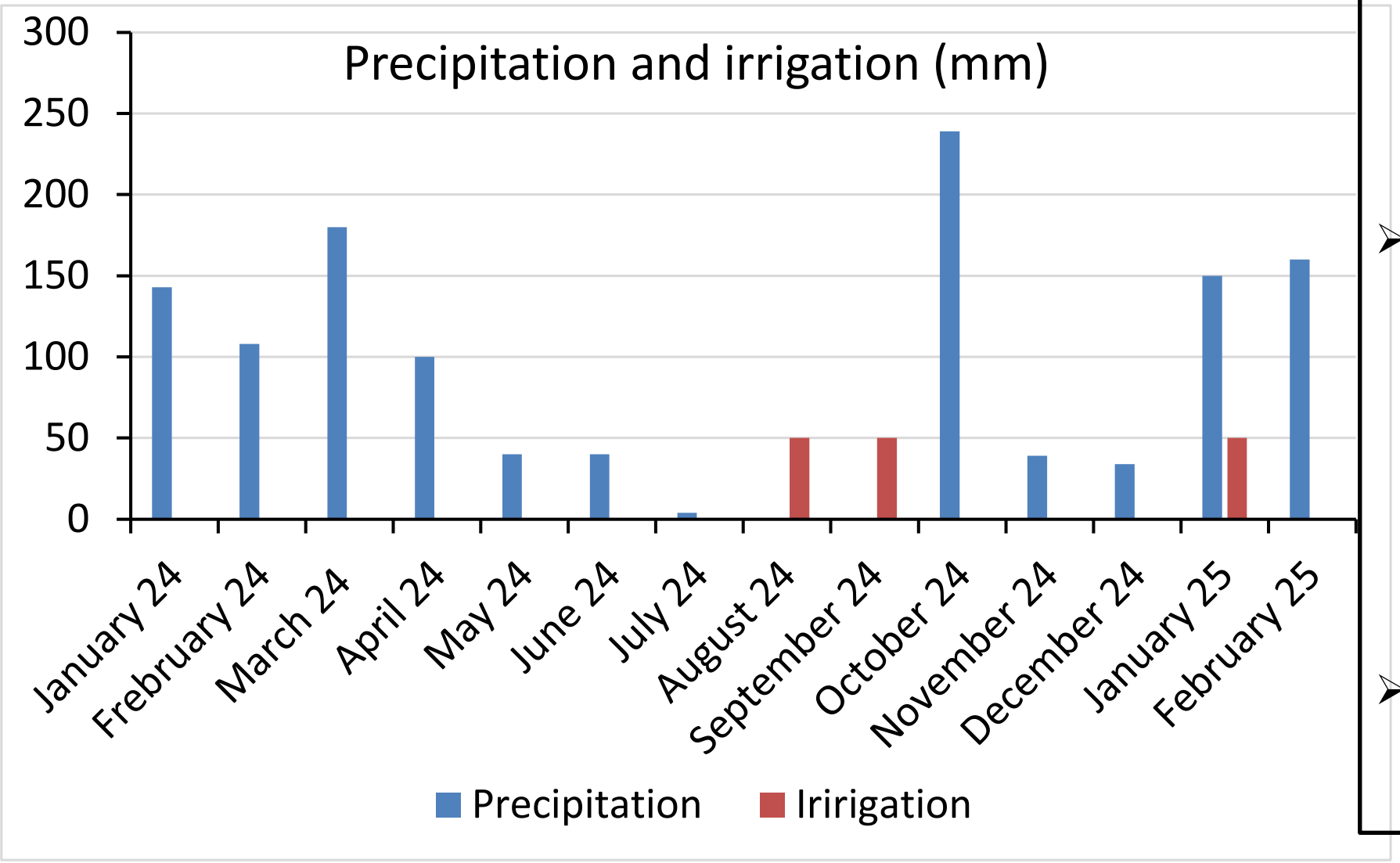
- 3 Carinata and wheat headling (09/2024)
- 4 Carinata and wheat harvesting (11/2024)

Temperatures during the crops cycle



- During the crop cycle there were an important number of days during which minimum temperatures were below cero, especially from the beginning of march to end of June Affecting winter crops (specially Carinata).
- In the same way during summer (January and February) there were maximum temperatures above 30 °C that were extended to some days during winter

Precipitation and irrigation 2024-2025



- The year 2024 starts with good precipitations during the autumn but during winter there was not precipitation and wheat and Carinata suffered the lack of water in the soil.
- Irrigation was applied in August and September (50 mm each) to compensate the lack of precipitations during winter that affected tillering and branches appearance in wheat and carinata.
  Cumalative precipitations during 2024 was 784 mm.
- During 2025 precipitation was increased accumulated up to February 310 mm

Soil Samples during 2024

Soil properties

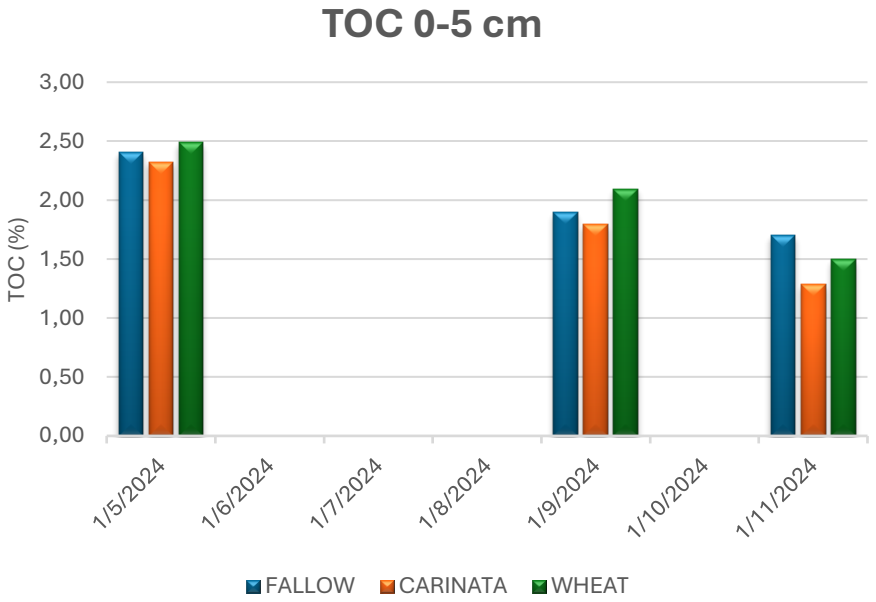
- Morphological and analitical Soil description
- 3 pits
- 1 m depth
- “Delgado” soil Serie

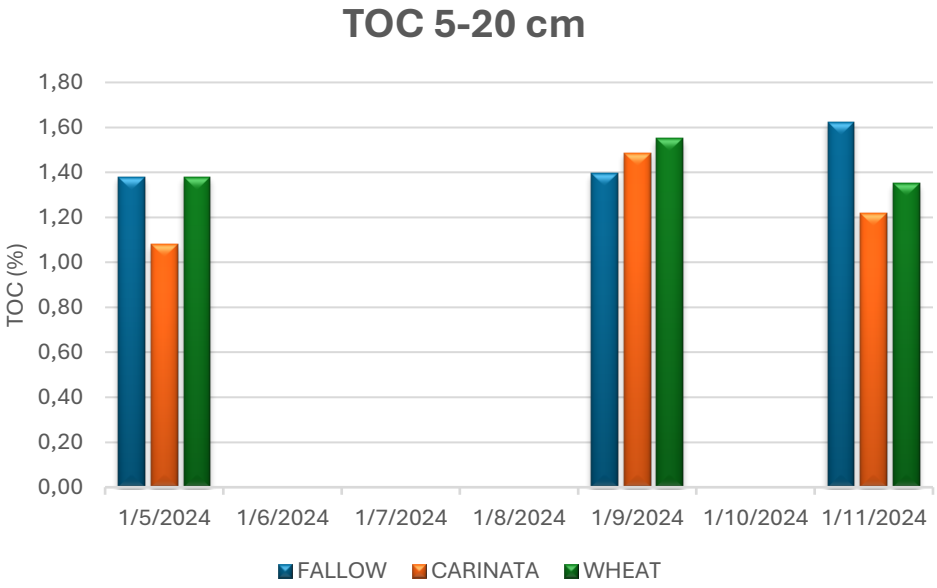
Delgado soil Serie

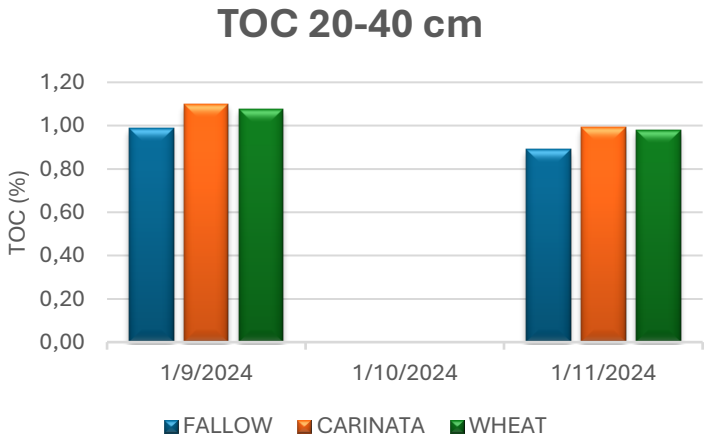
Horizon	A	BA	Bt	BC
	0-22 cm	22-42 cm	42-64 cm	96. m
Organic Matter OM (%)	3.15	3.11	2.27	2.13
Total organic carbon TOC (%)	1.83	1.80	1.31	1.23
NO3 (ppm)	41.00	11.71	2.33	1.18
N-NO3 (ppm)	8.07	2.30	0.46	0.23
Pext (ppm)	36.4	21.9	23.2	18.5
Clay (%)	20	24	22	14
Silt (%)	54.4	49.7	45.62	51.8
Sand (%)	25.6	26.3	32.38	34.2
CaCO3	-	-	-	-
EC (dS/m)	0.09	0.06	0.06	0.06
pH	4.83	4.41	5.06	5.15
Cations				
Ca2+ (cmolc/kg)	7.68	8.96	10.74	10.14
Mg2+ (cmolc/kg)	2.11	1.39	3.05	1.70
Na+ (cmolc/kg)	0.46	0.25	0.25	0.25
K+ (cmolc/kg)	2.29	1.85	2.34	2.80
CIC (cmolc/kg)	12.93	13.99	17.04	18.82

*Original data

Soil organic carbon (TOC)



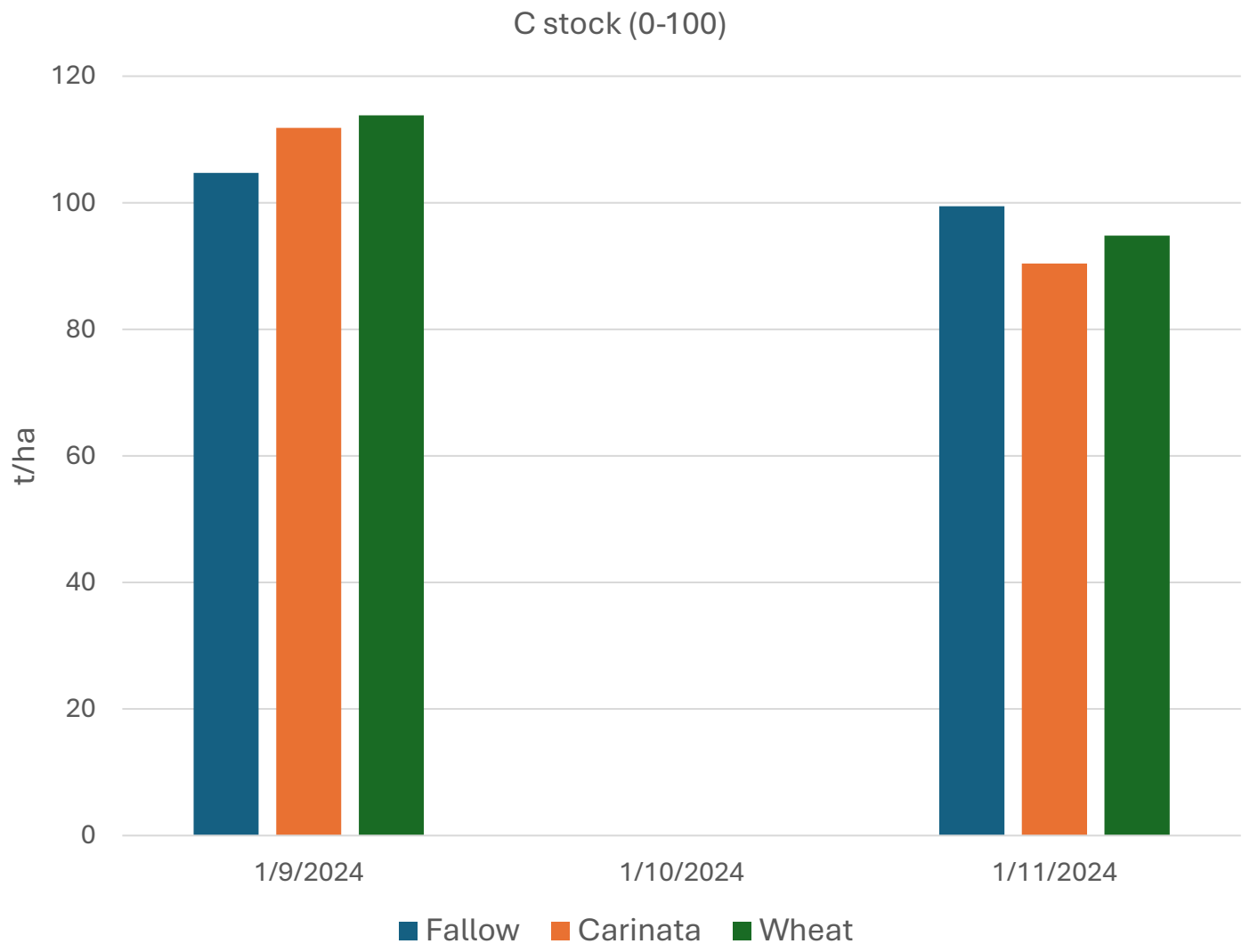




- Organic matter does not show significant differences among treatments at any depth.
- Organic matter decreased throughout the year only at a depth of 0-5 cm (drought?)
- A year seems like too little time to observe significant effects.

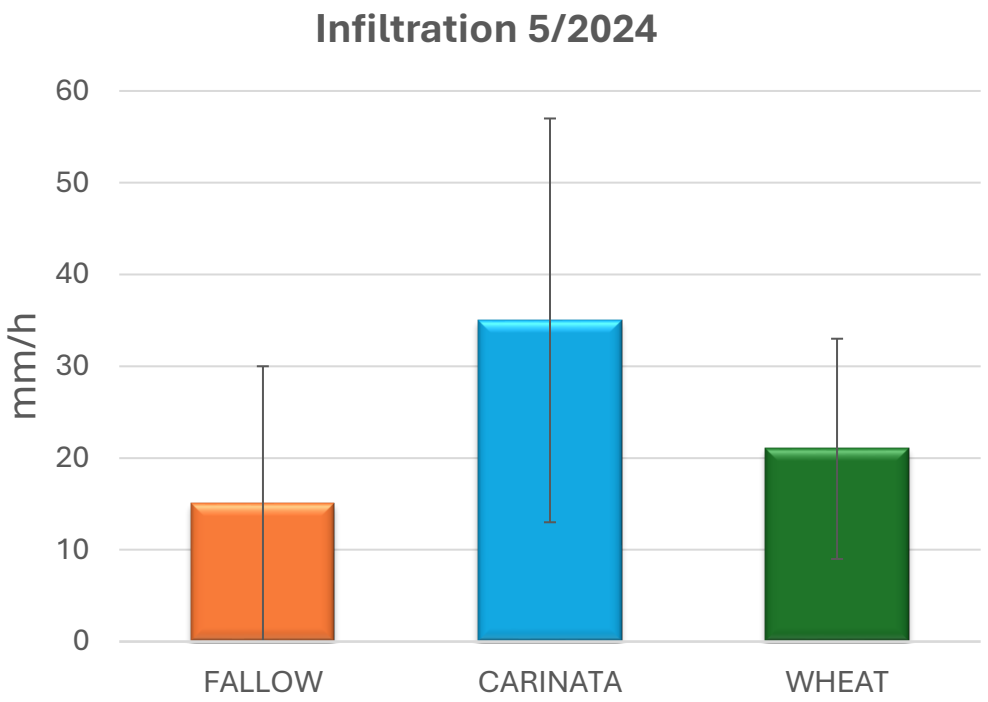
Soil Organic Carbon stock at 100 cm

- Soil organic carbon stock is the result of bulk density and OC concentration
- No significant treatment impact on Carbon stock yet.



Infiltration rate

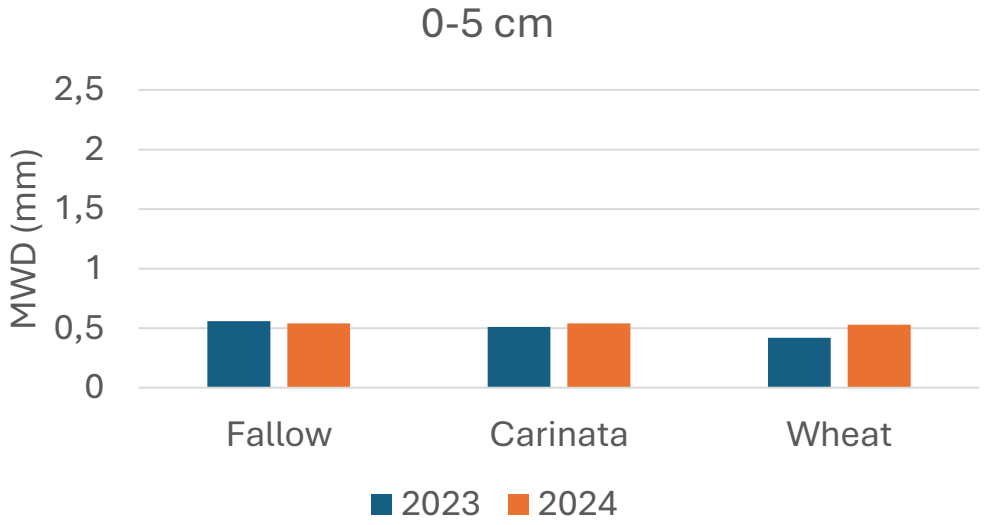
- High variability
- Carinata tended to have the highest infiltration rate after a year.
- Very heterogeneous plots?

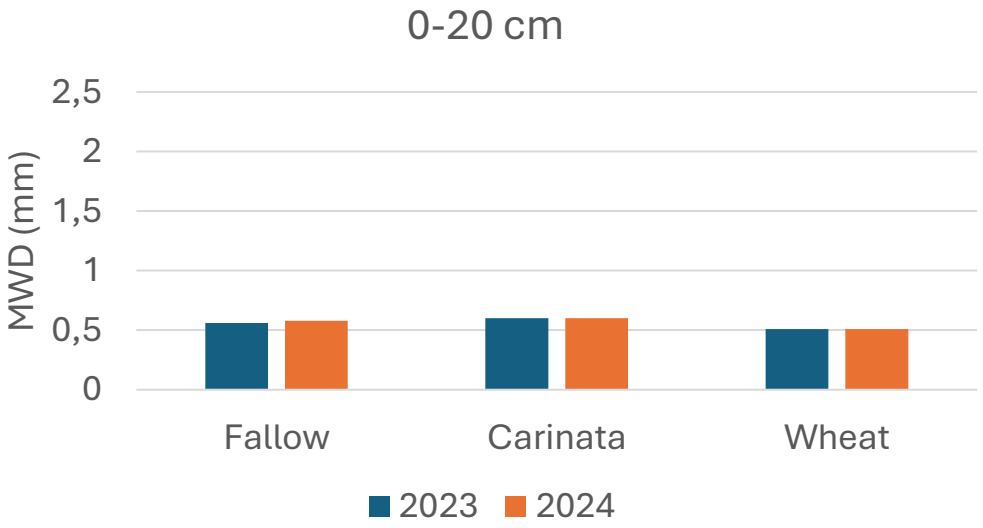


USDA Simple ring method

Soil Aggregate stability

- Low aggregate stability
- There were No significant differences among treatments
- No evolution in a year
- It appears to be consistent with the organic matter values

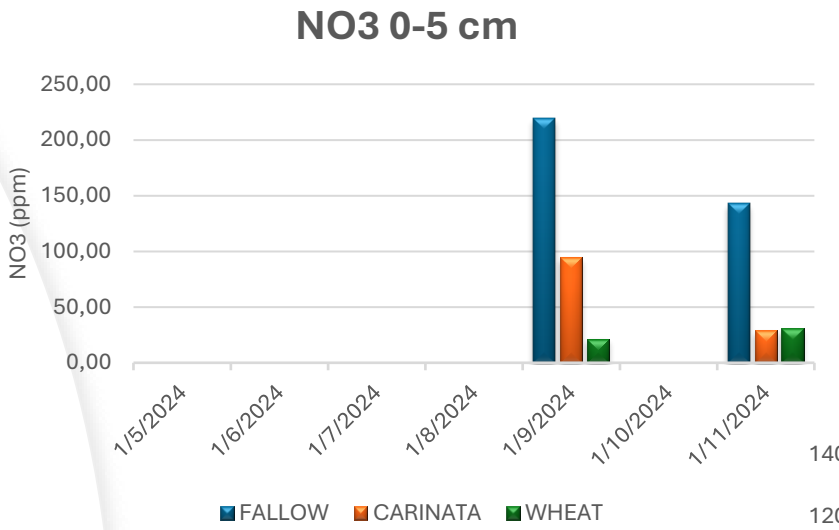


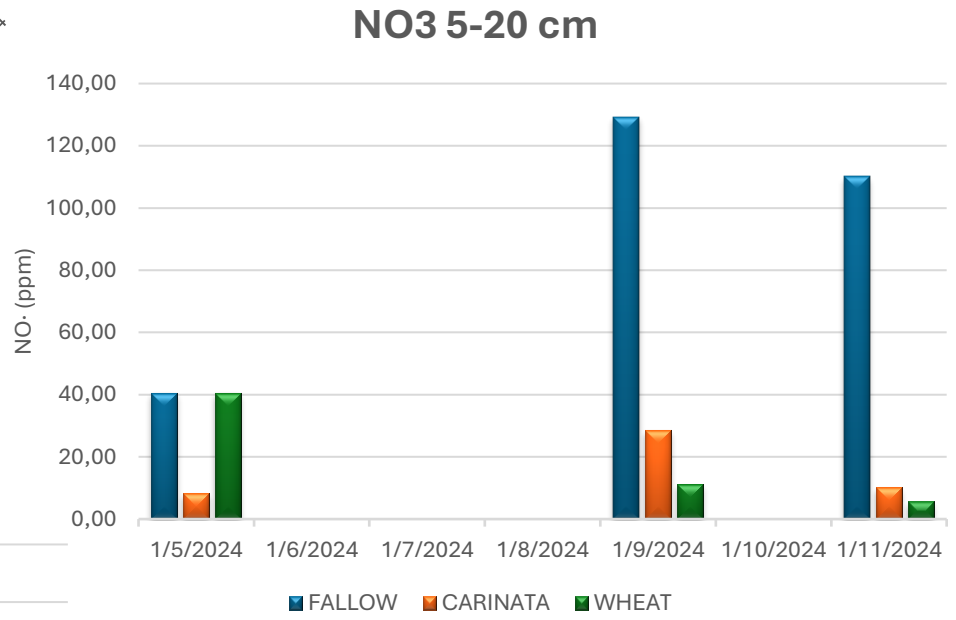


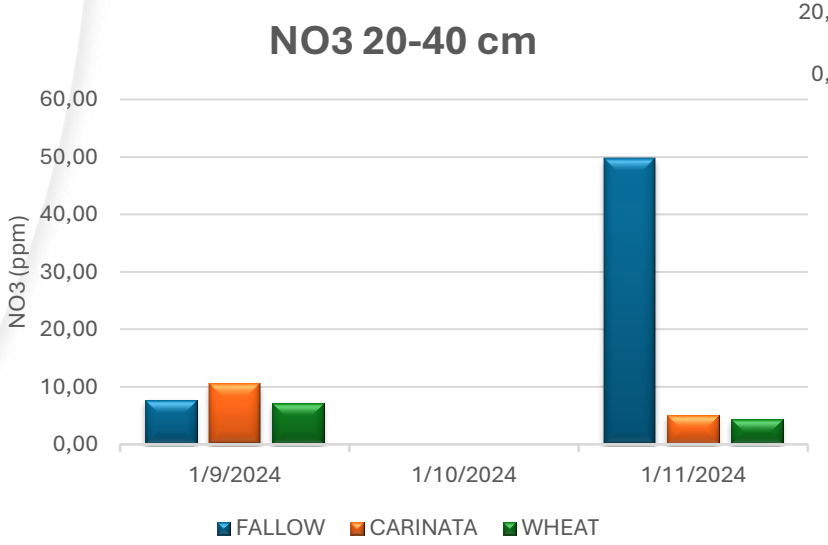
Main nutrients

NO3-

- The goal of measure nutrients is to relate with crop developement
- Very high and significative NO3- accumulation in fallow.
- There were no NO3- consumption by crops during fallow period.
- The scarce precipitation during the period contributed to an increase in nitrate concentration in the soil at 40 cm.

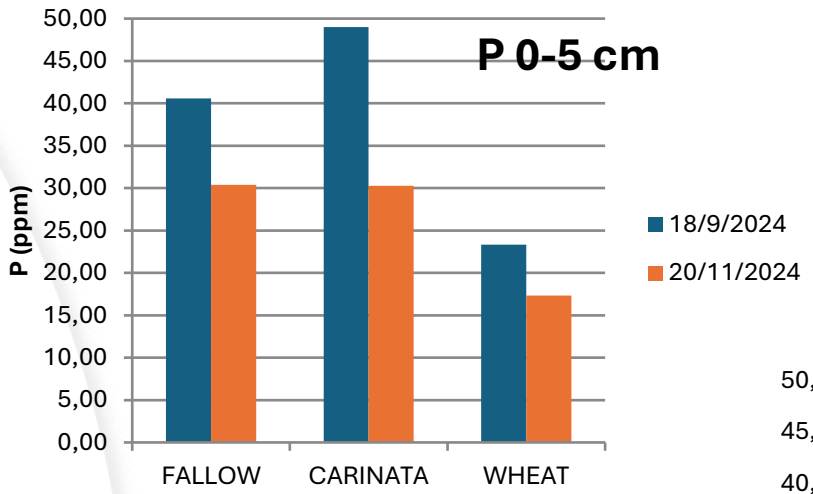


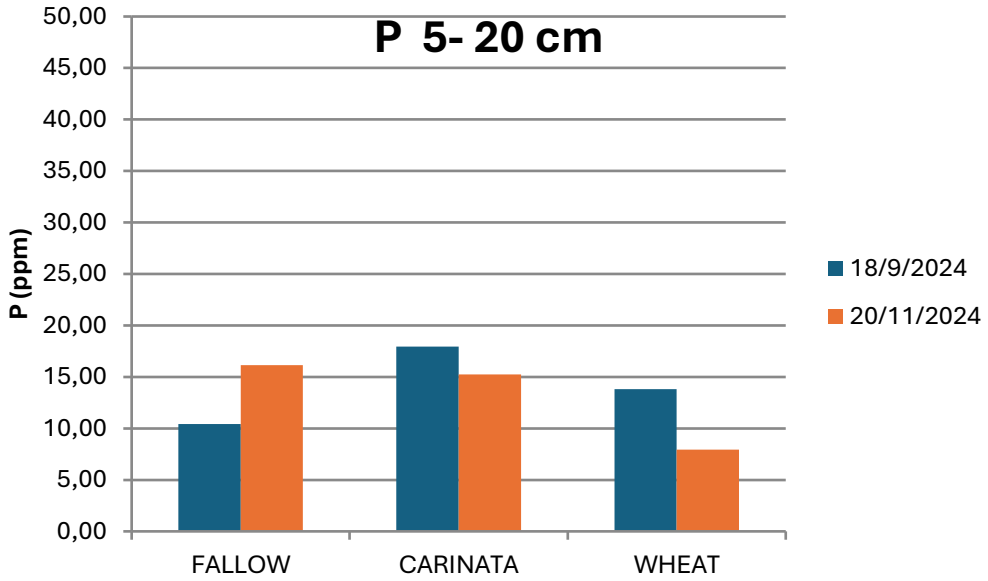


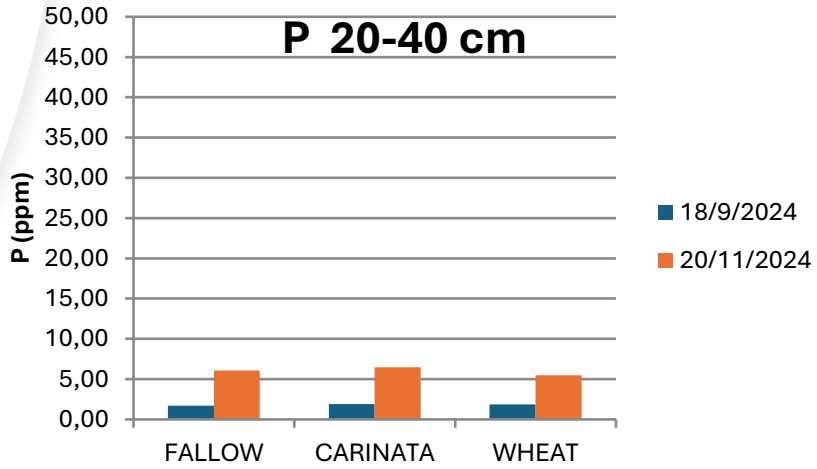


Phosphorus

- Well supplied with P
- No sig. differences between treatments
- Normal differences depth



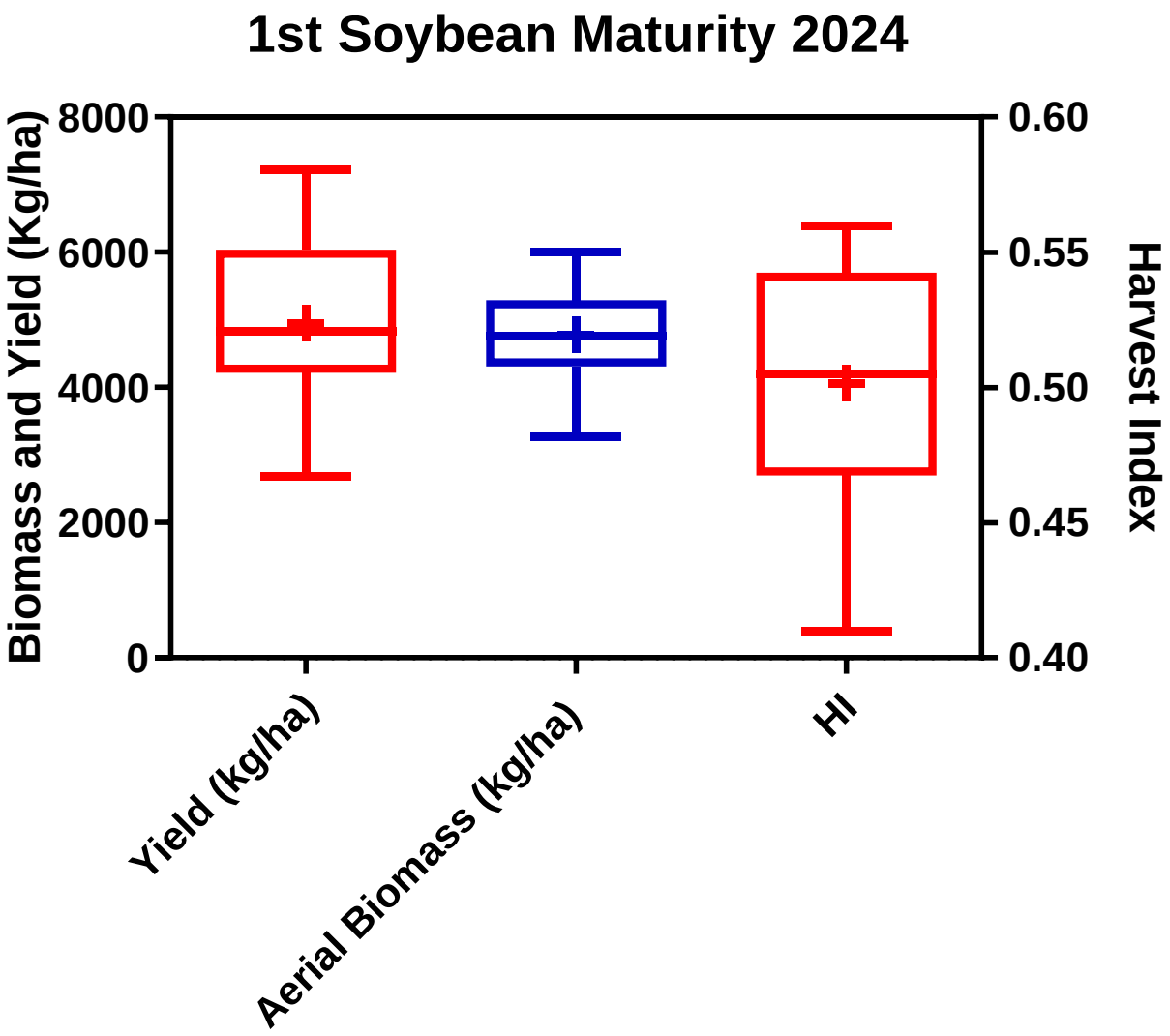




Crop Samples during 2024:

Soybean Results in monoculture and after Wheat and Carinata Crops

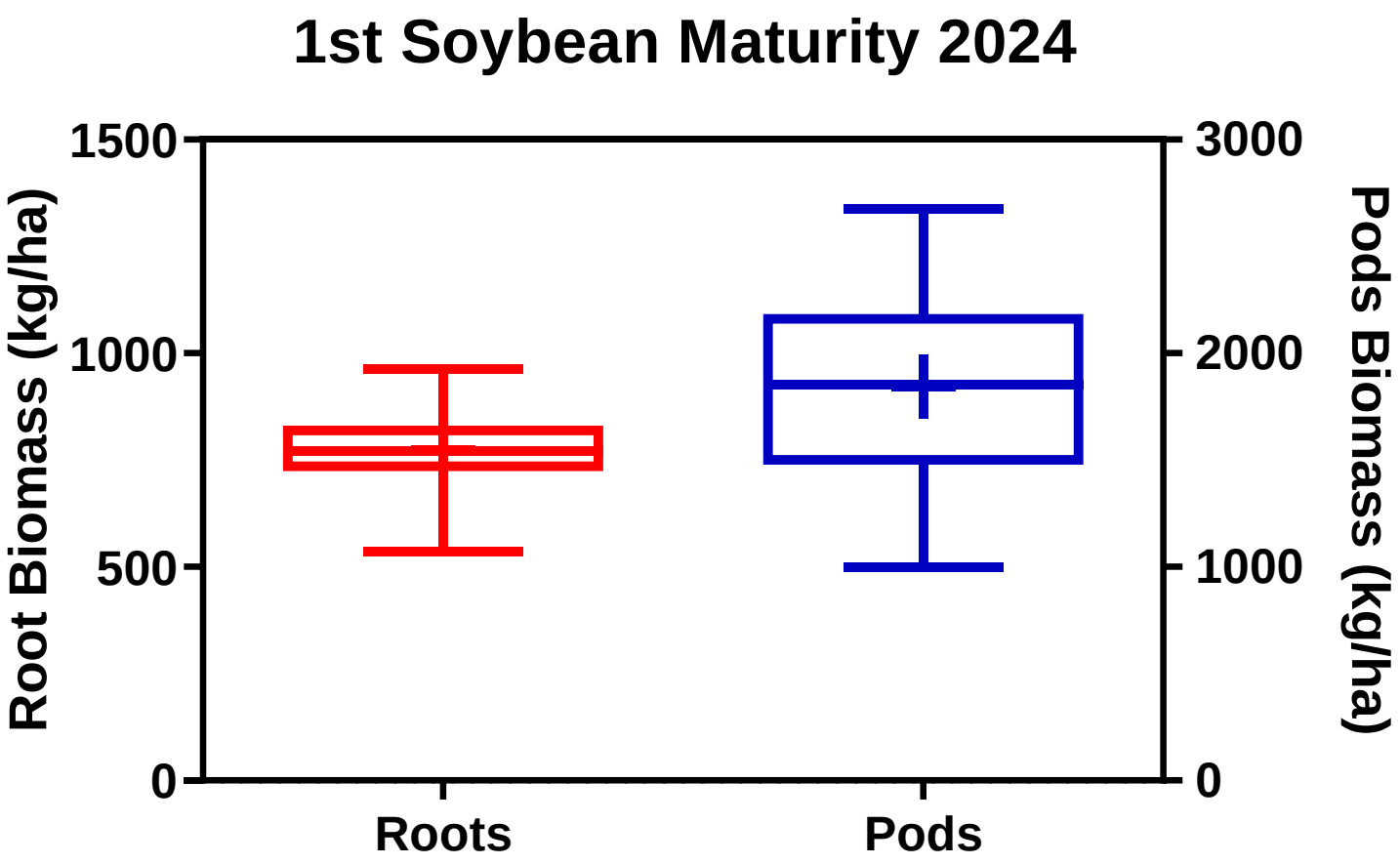
Soybean data at harvest in the monoculture treatment



- Soybean yield in the monoculture treatment (every year soybean as monoculture) showed yield values from 2.7 to 7.2 Ton/ha with a mean of 5 Tons/ha.
- Aerial biomass also showed important variation among samples from 3.3 to 6.0 Ton/ha with a mean of 4.8 Ton/ha at harvest.
- Harvest Index ranged from 0.4 to 5.6 with a mean of 0.5

	Yield (kg/ha)	Aerial Biomass (kg/ha)	HI
Minimum	2680	3271	0,4100
Maximum	7215	5997	0,5600
Range	4535	2726	0,1500
Mean	4950	4780	0,5017
Std. Deviation	1396	747,4	0,04409
Std. Error of Mean	328,9	176,2	0,01039

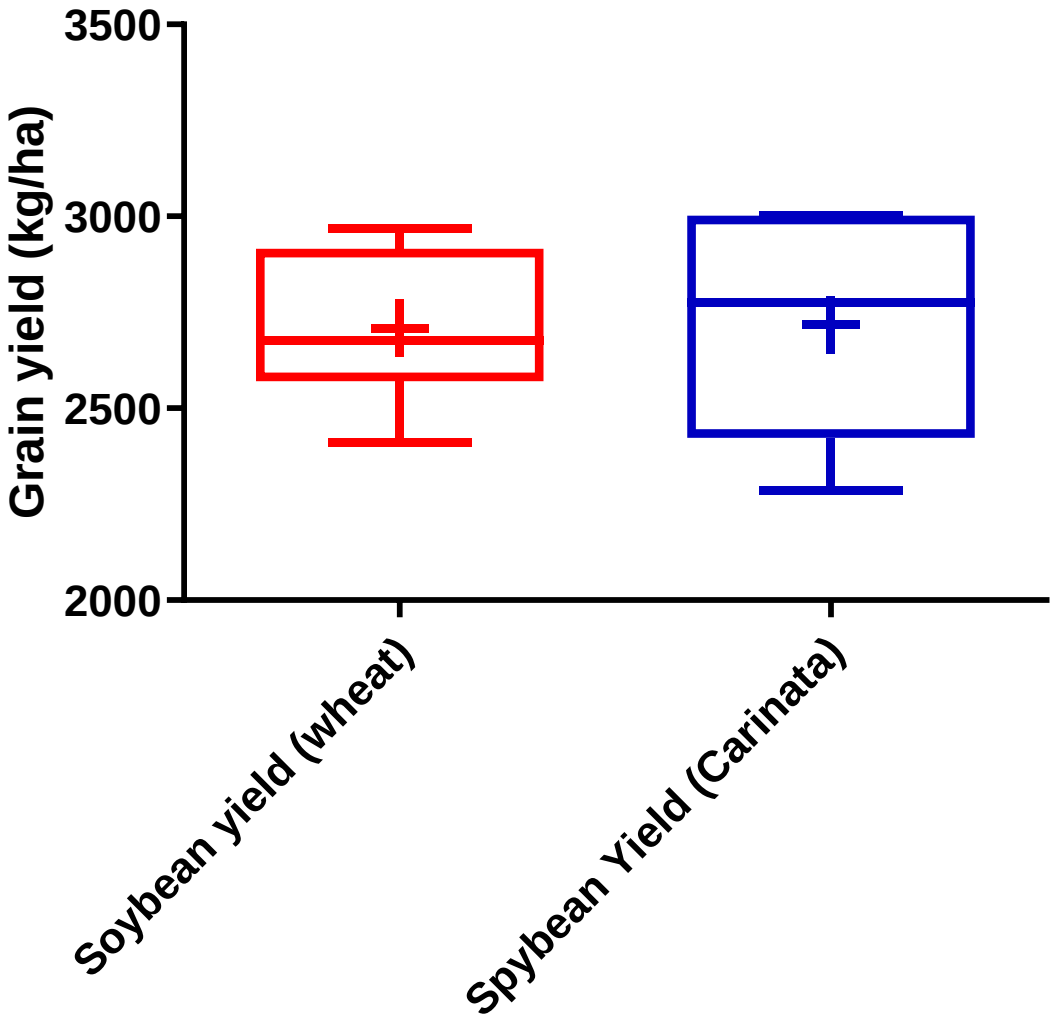
Soybean data at harvest in the monoculture treatment



- Soybean Root biomass ranges from 537 to 963 Kg/ha in soybean sown under monoculture.
- Pods biomass (without grains) ranged from 1000 to 2670 Kg/ha)

	Root Biomass	Pods Biomass
Minimum	537,4	999,0
Maximum	962,7	2673
Range	425,3	1674
Mean	774,7	1843
Std. Deviation	97,22	480,0
Std. Error of Mean	22,92	113,1

Soybean data at harvest for different previous crops



- Statistic analysis did not show significant differences in soybean yield when sown after wheat or Carinata crops with values close to 2,7 Ton/ha.
- Soybean in monoculture yield mores than the soybean that was sown after winter crops due to the shorter cycle (sowing date was in January 2024)

Yield (Kg/ha)

Variable	N	R^2	R^2 Aj	CV
Yield (Kg/ha)	12	4,4E-04	0,00	9,26

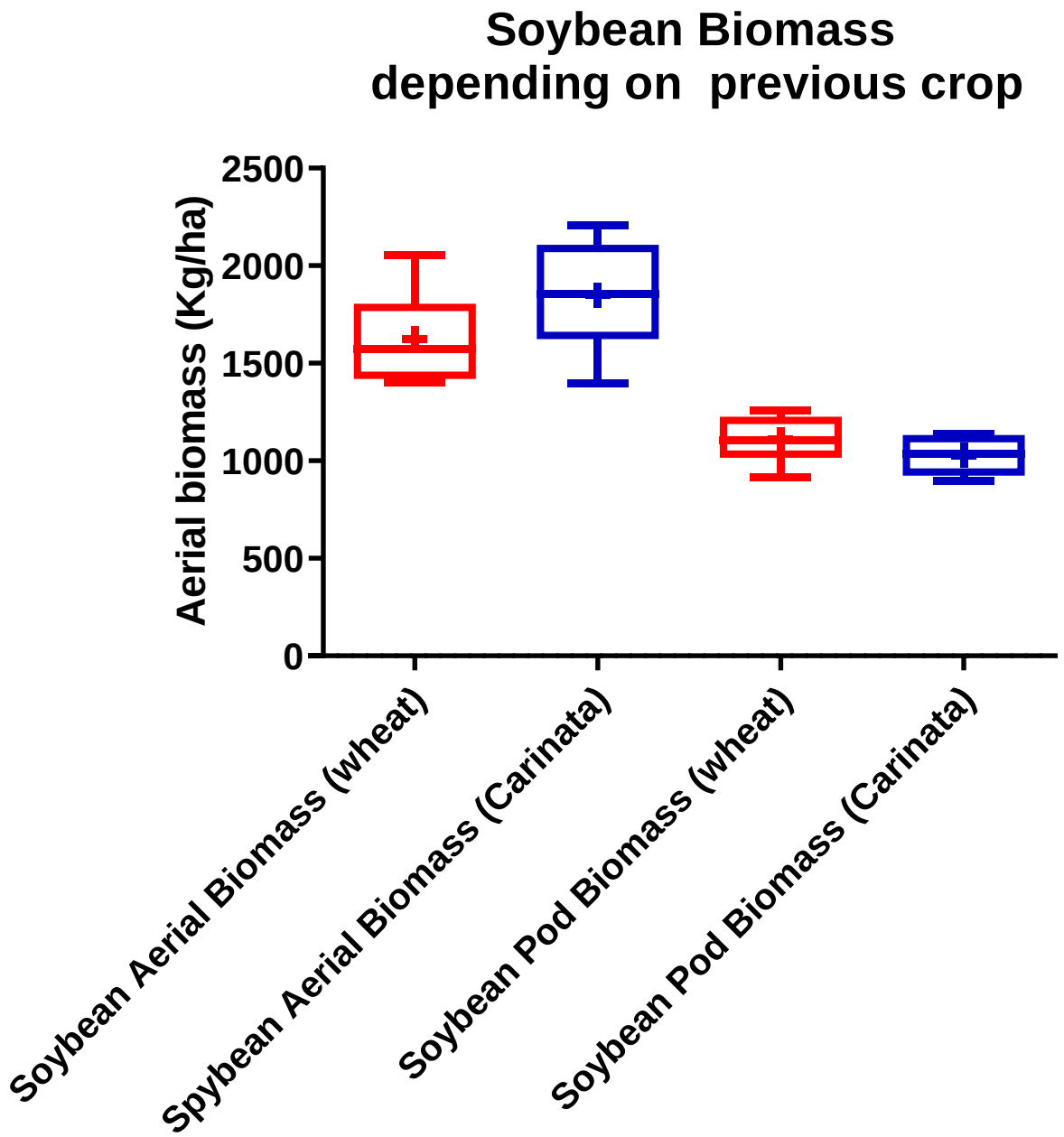
Cuadro de Análisis de la Varianza (SC tipo III)

F.V.	SC	gl	CM	F	p-valor
Modelo	280,33	1	280,33	4,4E-03	0,9482
Species	280,33	1	280,33	4,4E-03	0,9482
Error	630758,67	10	63075,87		
Total	631039,00	11			

Test:Tukey Alfa=0,05 DMS=323,08235 Error: 63075,8667 gl: 10

Species	Medias	n	E.E.	
Soybean-Carinata	2718,33	6	102,53	A
Soybean-Wheat	2708,67	6	102,53	A

Soybean data at harvest for different previous crops



- Soybean aerial biomass although was higher when the previous crops was carinata respect to wheat, the values were not significant in statistical terms.
- Similar response was observed in pods biomass

Aerial Biomass (Kg/ha)

Test:Tukey Alfa=0,05 DMS=342,88085

Error: 71043,3155 gl: 10

Specie	Medias	n	E.E.	
Soybean-Wheat	1848,50	6	108,81	A
Soybean-Carinata	1625,32	6	108,81	A

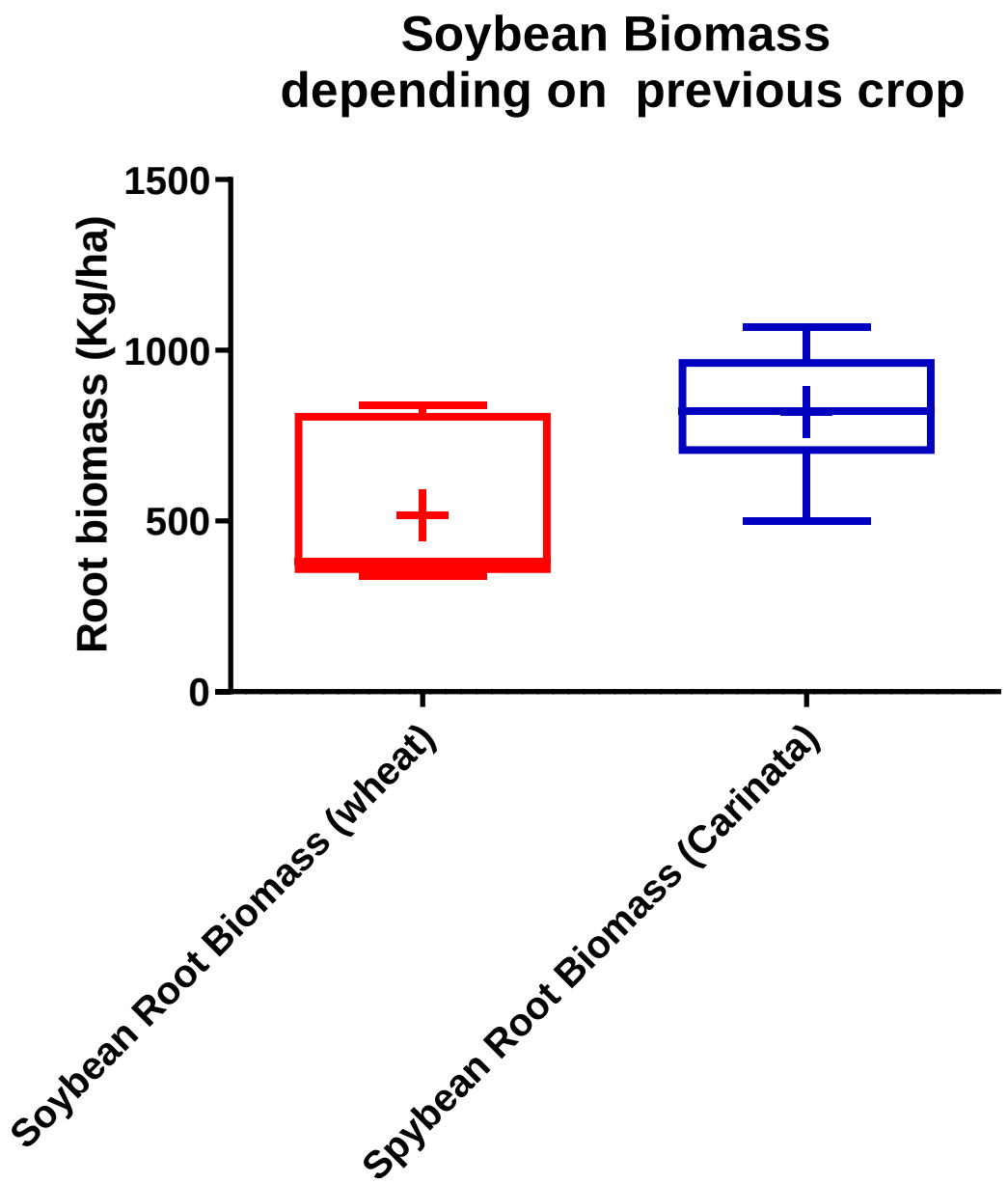
Pods Biomass (kg/ha)

est:Tukey Alfa=0,05 DMS=143,62089

Error: 12464,4167 gl: 10

Species	Medias	n	E.E.	
Soybean-Wheat	1108,67	6	45,58	A
Soybean-Carinata	1028,83	6	45,58	A

Soybean data at harvest for different previous crops



- Soybean root biomass was significantly higher when the previous crops was carinata respect to wheat.
- Root biomass (kg/ha) when the previous crop was Carinata was 373 Kg/ha while was 267 (kg/ha when the previous crop was wheat-

Root biomass Kg/ha)

Variable	N	R^2	R^2 Aj	CV	
Root Kg/ha)		12	0,58	0,54	15,55

Cuadro de Análisis de la Varianza (SC tipo III)

F.V.	SC	gl	CM	F	p-valor
Modelo	34133,33	1	34133,33	13,76	0,0040
Species	34133,33	1	34133,33	13,76	0,0040
Error	24809,33	10	2480,93		
Total	58942,67	11			

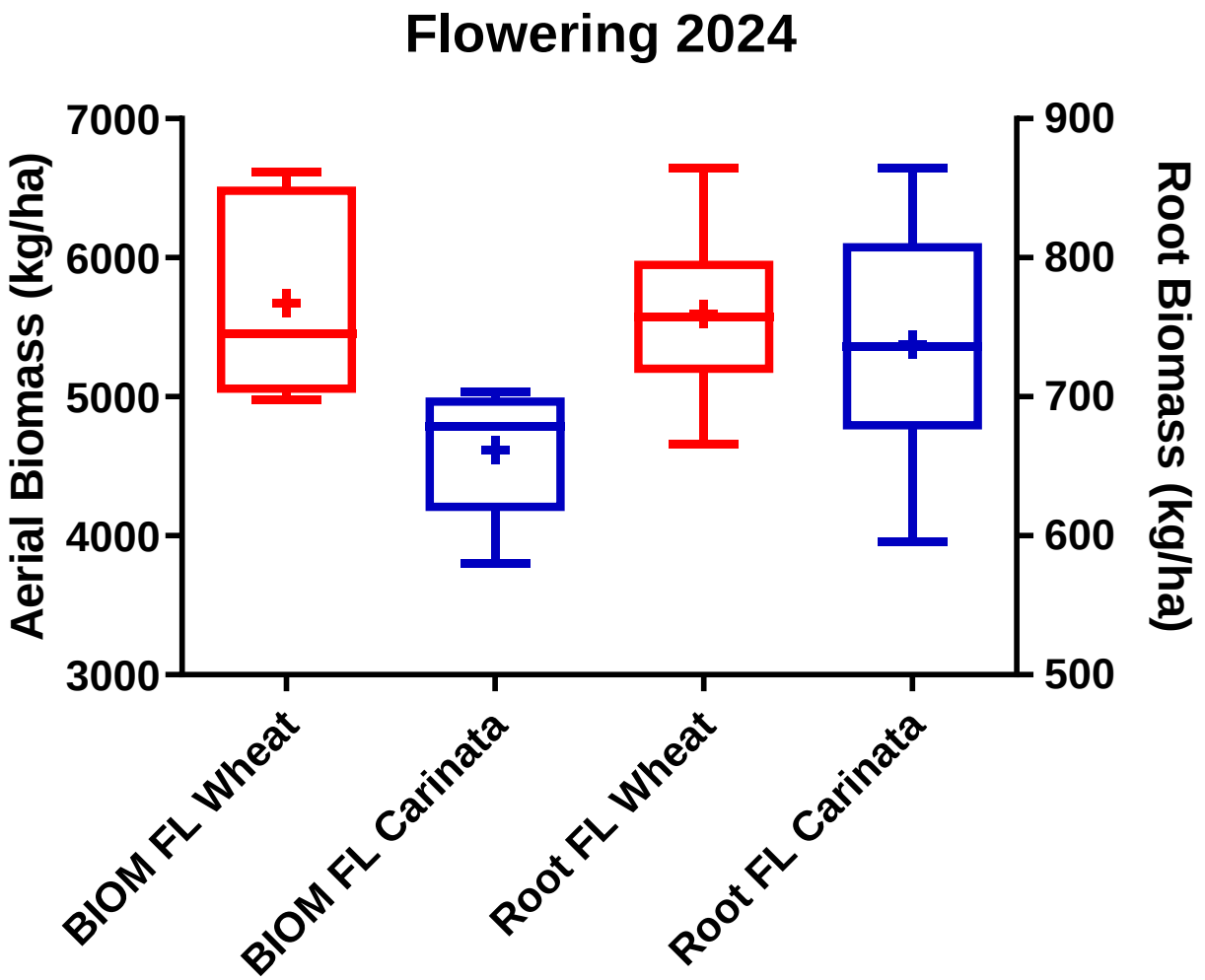
Test:Tukey Alfa=0,05 DMS=64,07508 Error: 2480,9333 gl: 10

Species	Medias	n	E.E.	
Soybean-Carinata	373,67	6	20,33	A
Soybean-Wheat	267,00	6	20,33	B

Crop Samples during 2024:

Wheat and Carinata Results

Wheat and Carinata results at Flowering into the rotation



- Both species showed significant differences in Aerial Biomass (kg/ha) at Flowering . Aerial Biomass at flowering in wheat was 5.6 Ton/ha and in Carinata was 4.6 Ton/ha. Thus, wheat produced 22% more aerial biomass at flowering than carinata .
- No significant differences was observed in root biomass at flowering with values around 0.74 Ton/ha in both species.

AERIAL BIOMASS (Kg/ha)

Test:Tukey Alfa=0,05 DMS=780,41491 gl: 10

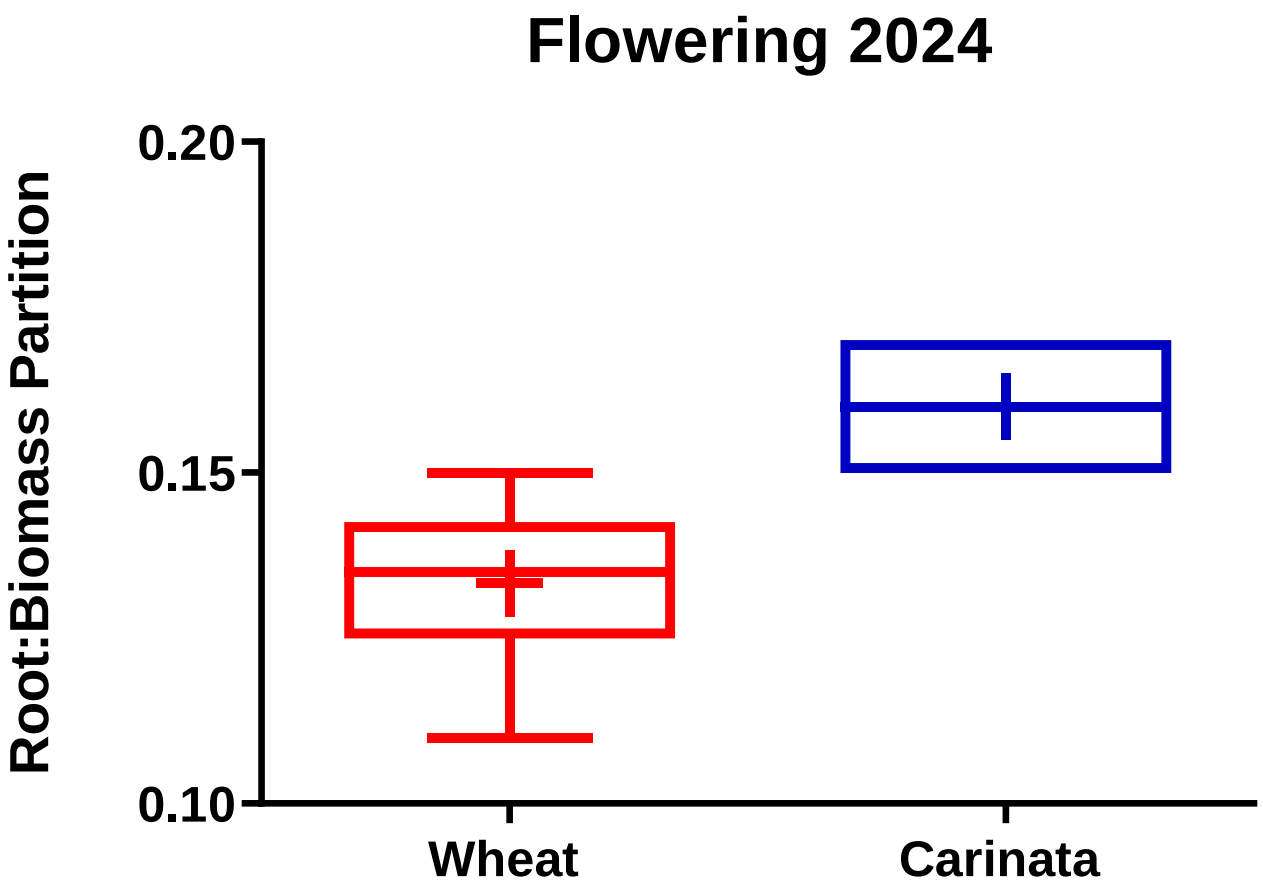
Specie	Medias	n	E.E.	
Wheat	5670,62	6	247,67	A
Carinata	4616,13	6	247,67	B

ROOT BIOMASS (Kg/ha)

Test:Tukey Alfa=0,05 DMS=100,63528 gl: 10

Specie	Medias	n	E.E.	
Wheat	759,17	6	31,94	A
Carinata	737,95	6	31,94	A

Wheat and Carinata results at Flowering into the rotation



- Significant differences were registered in biomass partitioning to the roots. Carinata showed at flowering significant higher partition (16%) respect to wheat (13%)

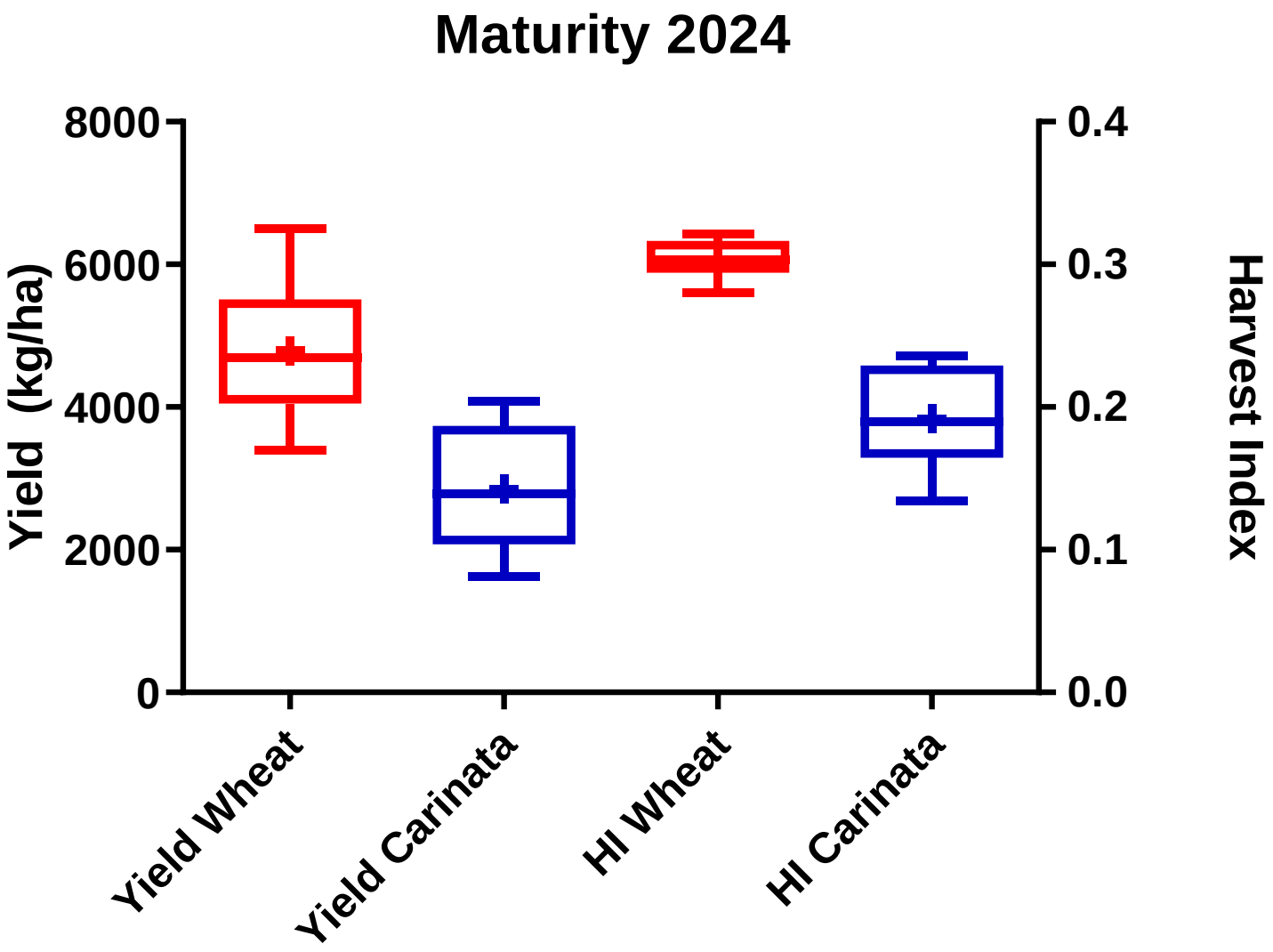
	Wheat	Carinata
Minimum	0,1100	0,1500
Maximum	0,1500	0,1700
Range	0,04000	0,02000
Mean	0,1333	0,1600
Std. Deviation	0,01366	0,008944
Std. Error of Mean	0,005578	0,003651

Root:Aerial Biomass Partition at Flowering

Test:Tukey Alfa=0,05 DMS=0,01444 gl: 9

Specie	Medias	n	E.E.		
Carinata	0,16	6	4,3E-03	A	
Wheat	0,13	5	4,7E-03		B

Wheat and Carinata results at Maturity into the rotation



- Grain yield was significantly higher in wheat than in carinata. Carinata represent 60% respect to the wheat yield. Yield in carinata was 2.8 Ton/ha while in wheat was 4.8 Ton/ha.
- Harvest index also was significantly higher in wheat (0.3) than in Carinata (0.19).

Grain Yield (Kg/ha)

Test:Tukey Alfa=0,05 DMS=1264,30736 gl: 10

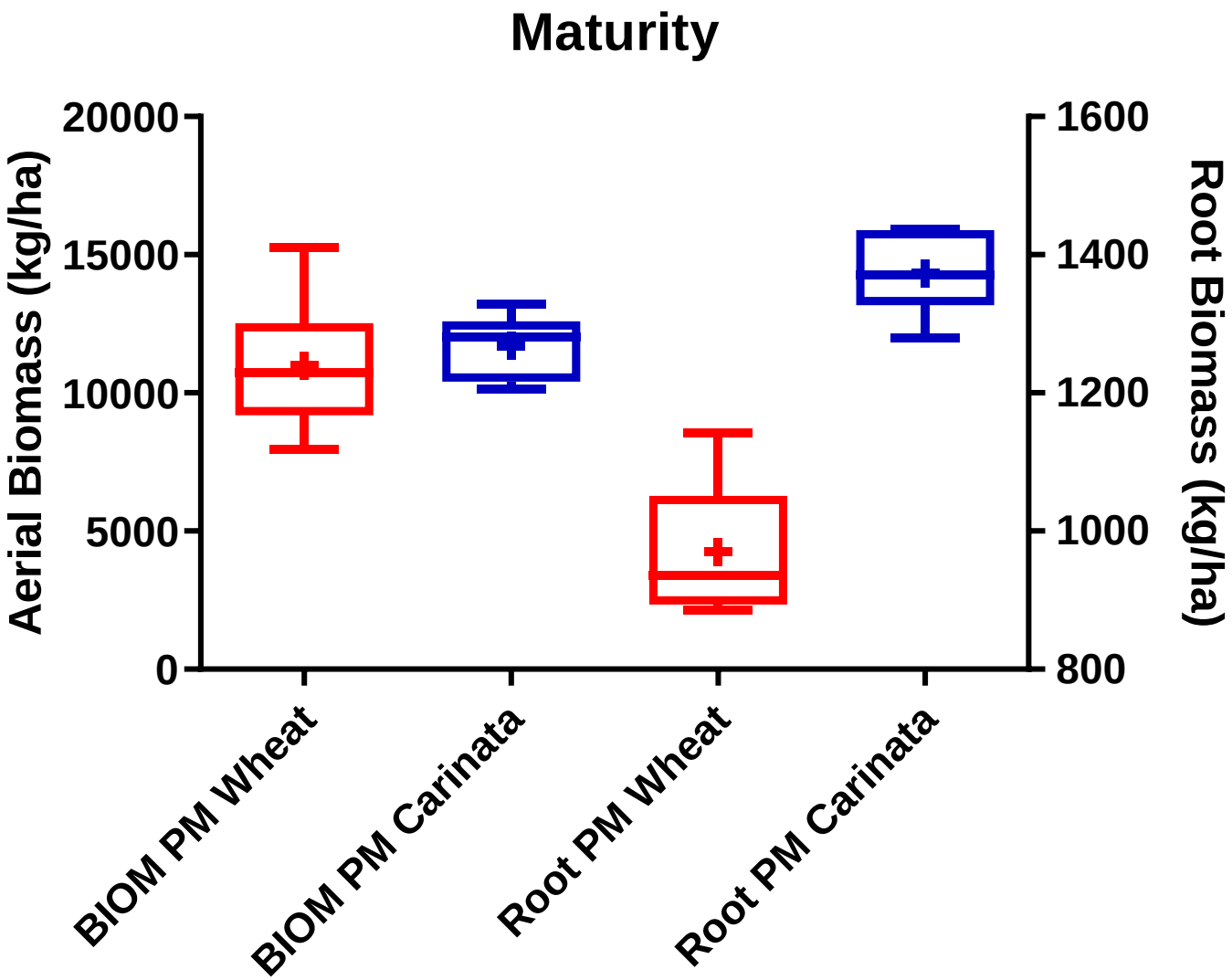
Specie	Medias	n	E.E.	
Trigo	4788,65	6	401,23	A
Carinata	2852,22	6	401,23	B

Harvest Index (HI)

Test:Tukey Alfa=0,05 DMS=0,03651 gl: 10

Specie	Medias	n	E.E.	
Trigo	0,30	6	0,01	A
Carinata	0,19	6	0,01	B

Wheat and Carinata results at Maturity into the rotation



- Aerial Biomass was similar at maturity between both species with ca. 11 Tons/ha.
- Root biomass was significantly different between wheat and Carinata. Carinata showed significantly higher root biomass 1.4 Ton/ha than wheat (0.97 Tons/ha)

Aerial Biomass (kg/ha)

Test:Tukey Alfa=0,05 DMS=2474,93524 gl: 10

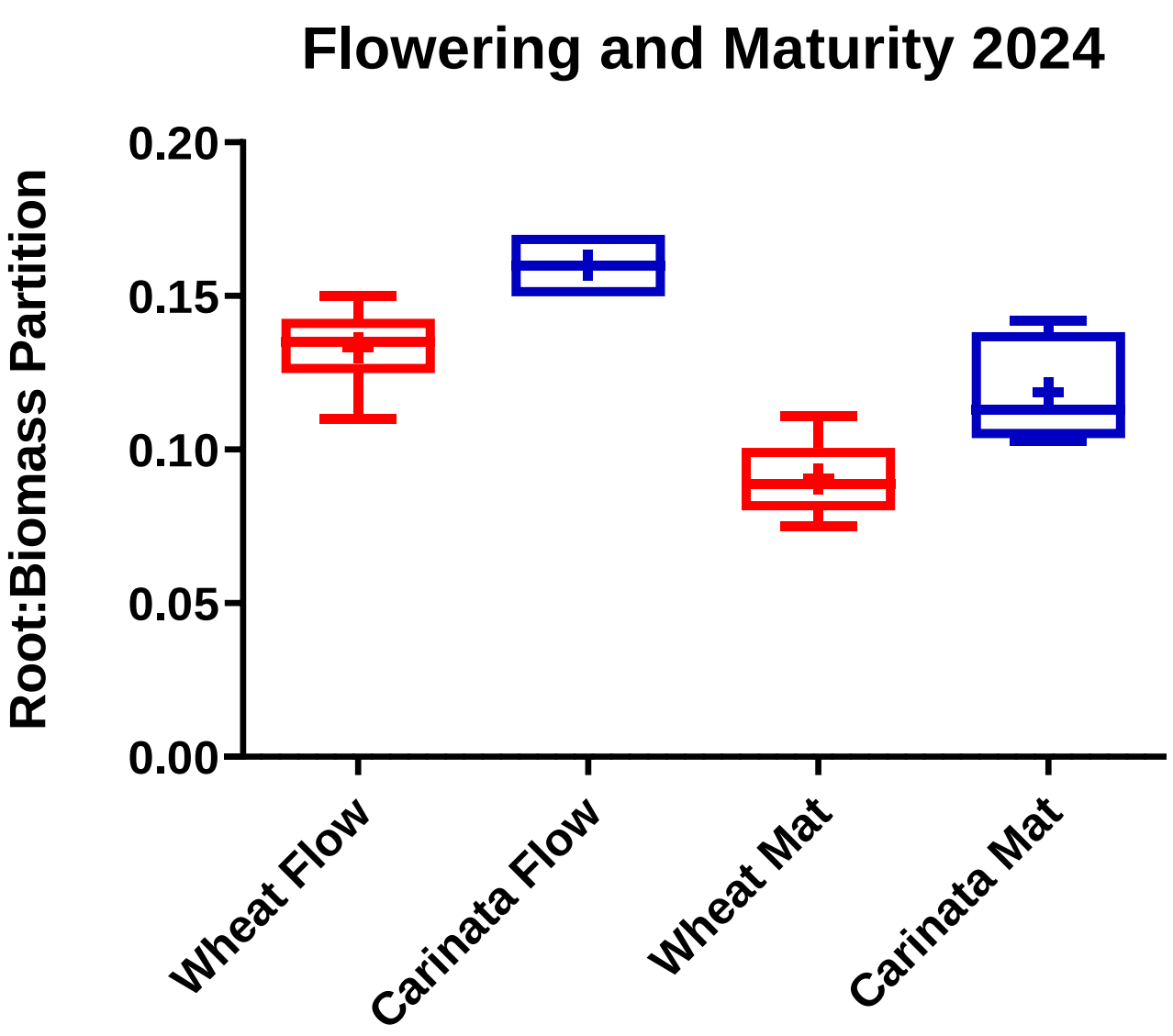
Specie	Medias	n	E.E.	
Carinata	11713,28	6	785,43	A
Trigo	10989,72	6	785,43	A

Root Biomass (kg/ha)

Test:Tukey Alfa=0,05 DMS=104,34018 gl: 10

Specie	Medias	n	E.E.		
Carinata	1372,75	6	33,11	A	
Trigo	969,37	6	33,11		B

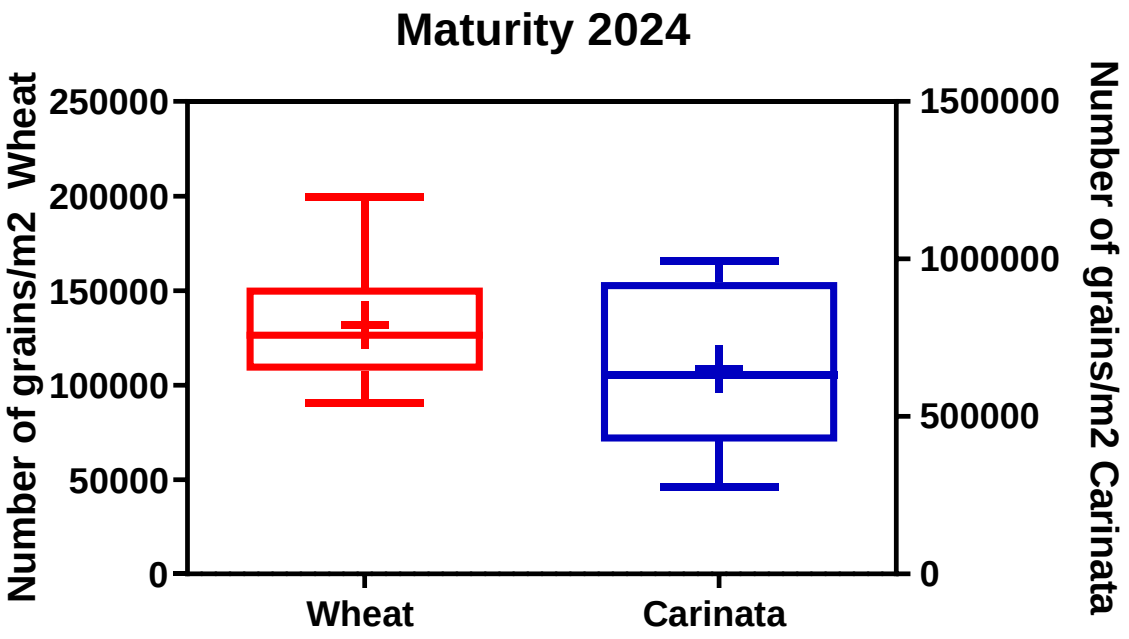
Wheat and Carinata results at Maturity into the rotation



- Root biomass partitioning respect to the aerial biomass was higher in Carinata than in wheat in both stages: Flowering and Maturity.
- Root biomass partitioning in carinata was 16 and 11% in flowering and maturity, while in wheat partitioning was 13 and 9% in the same stages.

	Flowering		Maturity	
	Wheat	Carinata	Wheat	Carinata
Minimum	0,1100	0,1500	0,07500	0,1030
Maximum	0,1500	0,1700	0,1110	0,1420
Range	0,04000	0,02000	0,03600	0,03900
Mean	0,1333	0,1600	0,09050	0,1187
Std. Deviation	0,01366	0,008944	0,01305	0,01681
Std. Error of Mean	0,005578	0,003651	0,005328	0,006864

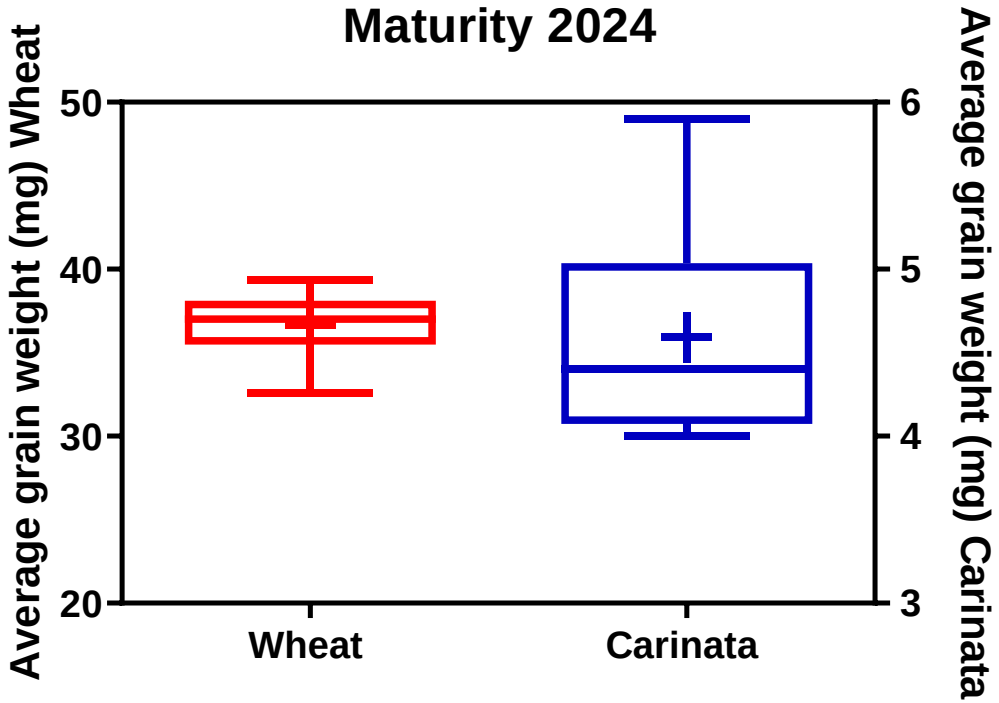
Wheat and Carinata results at Maturity into the rotation



Number of Grains per unit area

Test:Tukey Alfa=0,05 DMS=248028,57458 gl: 10

Specie	Medias	n	E.E.	
Carinata	651153,17	6	78712,64	A
Trigo	131976,67	6	78712,64	B



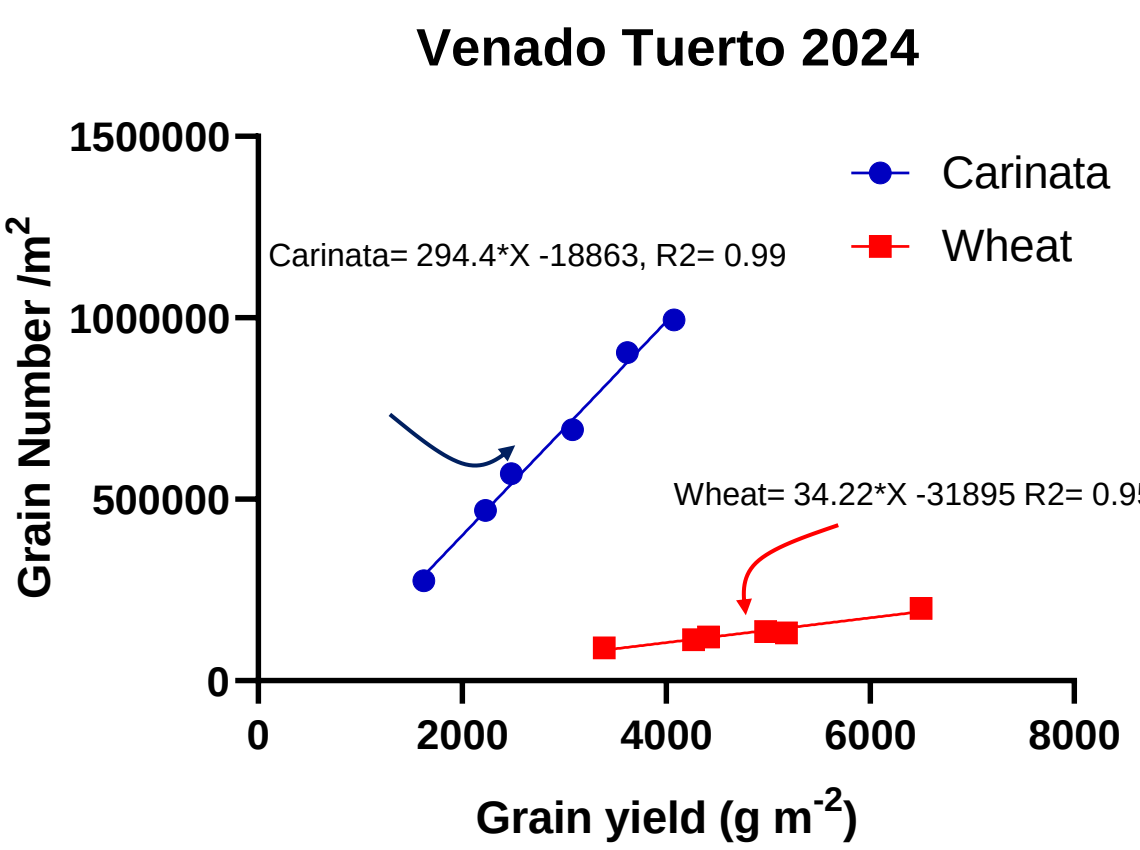
Average grain weight (mg)

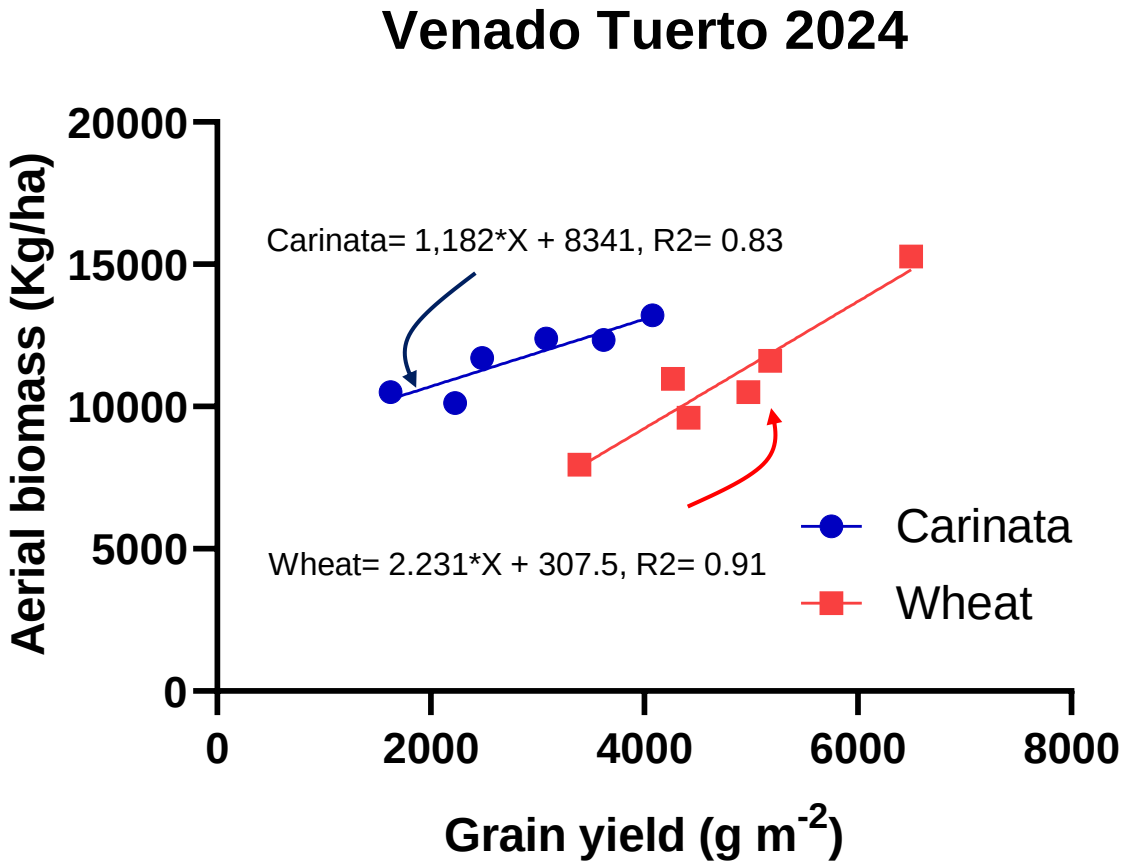
Test:Tukey Alfa=0,05 DMS=2,14466 ggl: 10

Specie	Medias	n	E.E.	
Trigo	36,69	6	0,68	A
Carinata	4,59	6	0,68	B

- Significant differences were observed in the number of grains per unit area as Carinata produced larger values than wheat.
- Average grain weight as was expected was significantly higher in wheat (36.7 mg) than in Carinata (4.6 mg)

Wheat and Carinata results at Maturity into the rotation





- Significant differences were observed in the number of grains per unit area as Carinata produced larger values than wheat.
- Average grain weight as was expected was significantly higher in wheat (36.7 mg) than in Carinata (4.6 mg)

Concluding remarks

Crops I

- Soybean sown early in the monoculture rotation showed higher yield than soybean sowing after Wheat and Carinata, which is expected as sowing date in monoculture sowing was earlier than soybean after winter crops.
- Statistic analysis did not show significant differences in soybean yield when sown after wheat or Carinata crops with values close to 2,7 Ton/ha.
- Soybean aerial biomass although was higher when the previous crops was Carinata respect to wheat, the values were not significant in statistical terms.
- Soybean root biomass was significantly higher when the previous crops was Carinata respect to wheat. Thus, root biomass (kg/ha) when the previous crop was Carinata was 373 Kg/ha while was 267 (kg/ha when the previous crop was wheat

Concluding remarks

Crops II

- In relation with winter crops, both species (wheat and Carinata) showed significant differences in Aerial Biomass (kg/ha) at Flowering with higher aerial Biomass in wheat than in Carinata. However, although no significant differences was observed in root biomass at flowering between wheat and Carinata, Carinata showed significant higher root partitioning respect to wheat contributing with 0.7 Ton/ha
- At maturity Carinata also showed higher root partitioning and higher biomass than wheat with Root biomass values of 1.4 Tons/ha.
- As was expected wheat over yielded Carinata which yielded 60% respect to the wheat yield.
- In both species yield was closely related to the variations in grains per unit area as well as to aerial biomass.

Concluding remarks

Soil

- Up to now, the treatments do not appear to significant influence the soil organic carbon concentration.
- The carbon stock shows the absence of a response to the treatments
- The soil physical properties (aggregate stability and infiltration) align with the lack of response of organic carbon until now

2024/2025

Rotation: Soybean as monoculture

Rotation: Carinata/Soybean

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