CARBON FARMING: A KEY CONTRIBUTION TO CARBON NEUTRALITY AND FOOD SECURITY

“Performance of agricultural practices for carbon sequestration”

Andrea Fiorini [1,2],

[1] Innovation for Sustainable Agriculture R&D.

[2] Department of Sustainable Crop Production, Università Cattolica del Sacro Cuore.

31/03/2023 Brussels, Rue Montoyer 21

EUROPEAN
COMMISSION

Brussels, 15.12.2021
COM(2021) 800 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Sustainable Carbon Cycles

Carbon farming practices

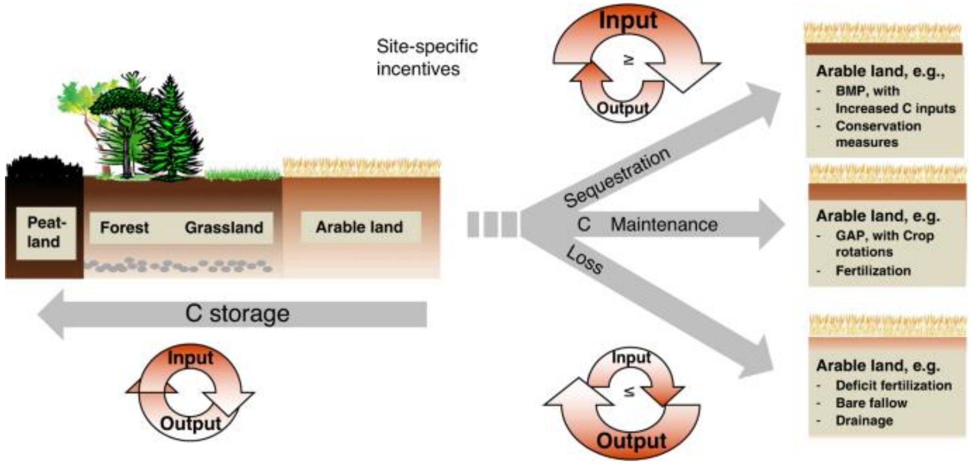
The potential for carbon removals, emission reductions and protection of existing carbon stocks varies according to bioclimatic conditions […]. Although very site-dependent in application, the following are effective examples of improved land management practices that result in the increase of carbon sequestration […]:

- Afforestation and reforestation that respect ecological principles favorable to biodiversity and enhanced sustainable forest management […] and adaptation of forests to climate change;
- Agroforestry and other forms of mixed farming combining woody vegetation (trees or shrubs) with crop and/or animal production systems on the same land;
- Use of catch crops, cover crops, conservation tillage and increasing landscape features: protecting soils, reducing soil loss by erosion and enhancing soil organic carbon on degraded arable land;
- Targeted conversion of cropland to fallow or of set-aside areas to permanent grassland;
- Restoration of peatlands and wetlands that reduces oxidation of the existing carbon stock and increases the potential for carbon sequestration.

R&D

UNIVERSITÀ
CATTOLICA
del Sacro Cuore

Arable lands: intensively managed (agro)ecosystems



Soil-specific options for carbon sequestration (exemplarily):

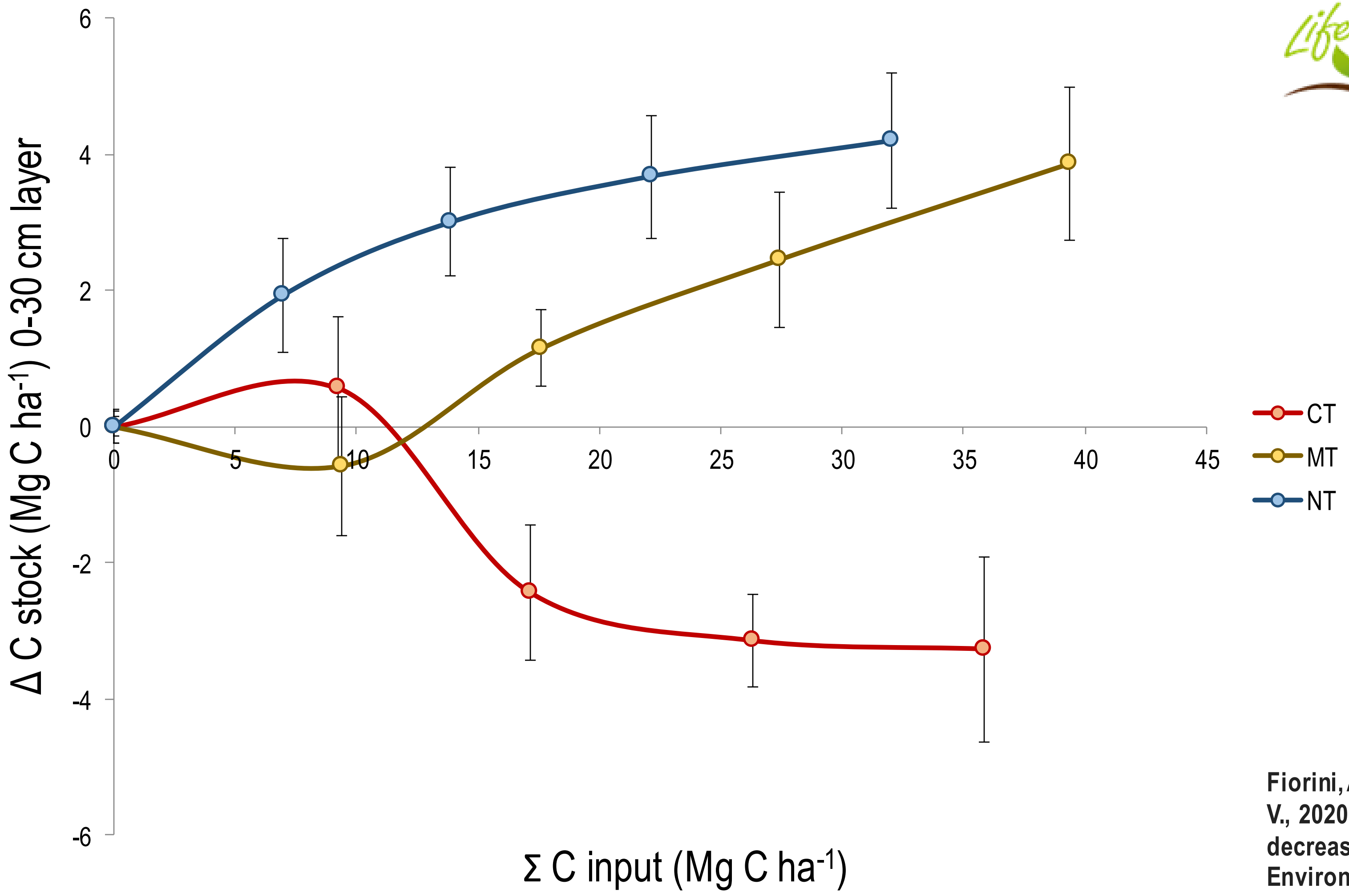
Predominant soil types: Alfisols, Inceptisols, Vertisols

Option 1. Reduced and/or no tillage (reducing C oxidation)

Option 2. Residue retention (increasing C inputs)

Amelung, W., Bossio, D., de Vries, W., Kögel-Knabner, I., Lehmann, J., Amundson, R., Bol, R., Collins, C., Lal, R., Leifeld, J. and Minasny, B., 2020. Towards a global-scale soil climate mitigation strategy. Nature communications, 11(1), p.5427.

Tillage management and soil C storage



Soil texture: clay loam

Crop sequence: maize monoculture

Initial SOC: 12.1 g kg^{-1}

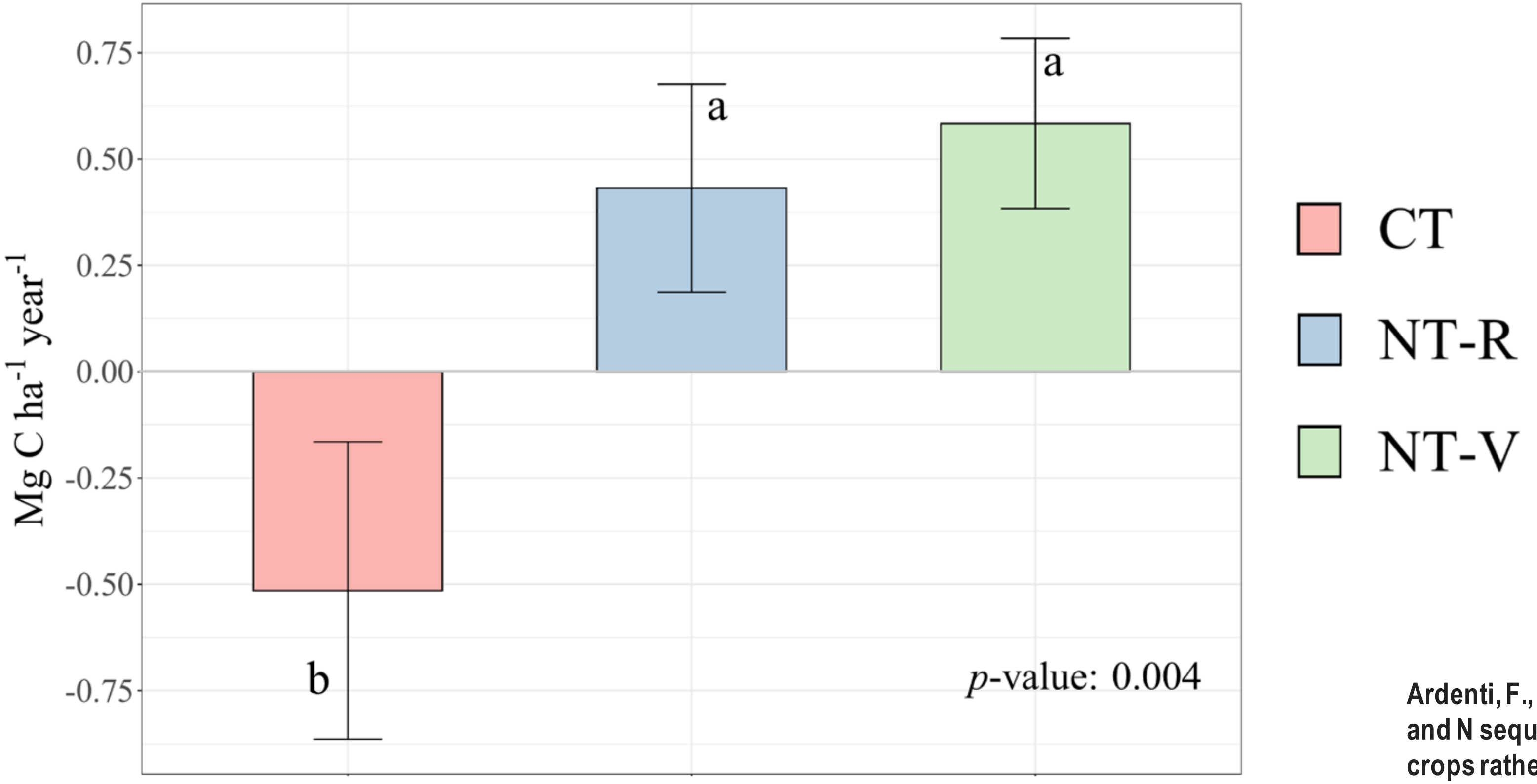
C sequestration ranking:

1. **No-till (NT)**
   +0.42 ± 0.08 **Mg C ha^{-1} yr^{-1}**
2. **Minimum tillage (MT)**
   +0.36 ± 0.11 **Mg C ha^{-1} yr^{-1}**
3. **Conventional tillage (CT)**
   -0.32 ± 0.13 **Mg C ha^{-1} yr^{-1}**

Fiorini, A., Boselli, R., Maris, S.C., Santelli, S., Ardenti, F., Capra, F. and Tabaglio, V., 2020. May conservation tillage enhance soil C and N accumulation without decreasing yield in intensive irrigated croplands? Agriculture, Ecosystems & Environment, 296, p.106926.

No-till plus cover crops to steer C cycling

C sequestration rate



Cover agroecologiche

Soil texture: silty clay

Crop seq.: maize-soybean-w.wheat

Initial SOC: 13.3 g kg^{-1}

C sequestration ranking:

1. **No-till + hairy vetch CC (NT-V)**
   +0.58 ± 0.21 **Mg C ha^{-1} yr^{-1}**
2. **No-till + rye CC (NT-R)**
   +0.46 ± 0.24 **Mg C ha^{-1} yr^{-1}**
3. **Conventional tillage (CT)**
   -0.51 ± 0.27 **Mg C ha^{-1} yr^{-1}**

Ardenti, F., Capra, F., Lommi, M., Fiorini, A. and Tabaglio, V., 2023. Long-term C and N sequestration under no-till is governed by biomass production of cover crops rather than differences in grass vs. legume biomass quality. Soil and Tillage Research, 228, p.105630.

GHG emissions and net CO2eq. storage

Life HelpSoil

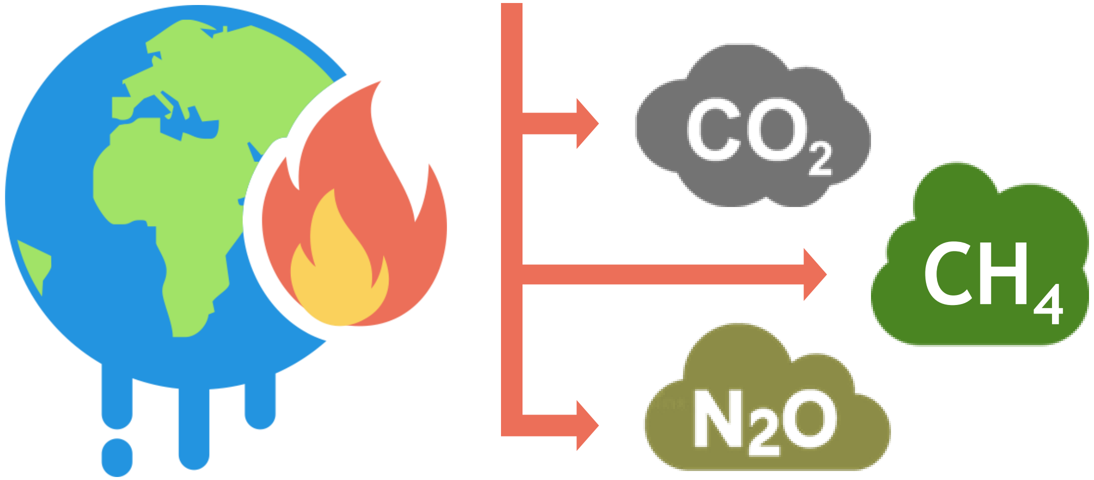
Optimagri

FCSR Cover agroecologiche

C sequestration potential of **no-till + CC**:
around **+0.5** Mg C ha^{-1} yr^{-1}

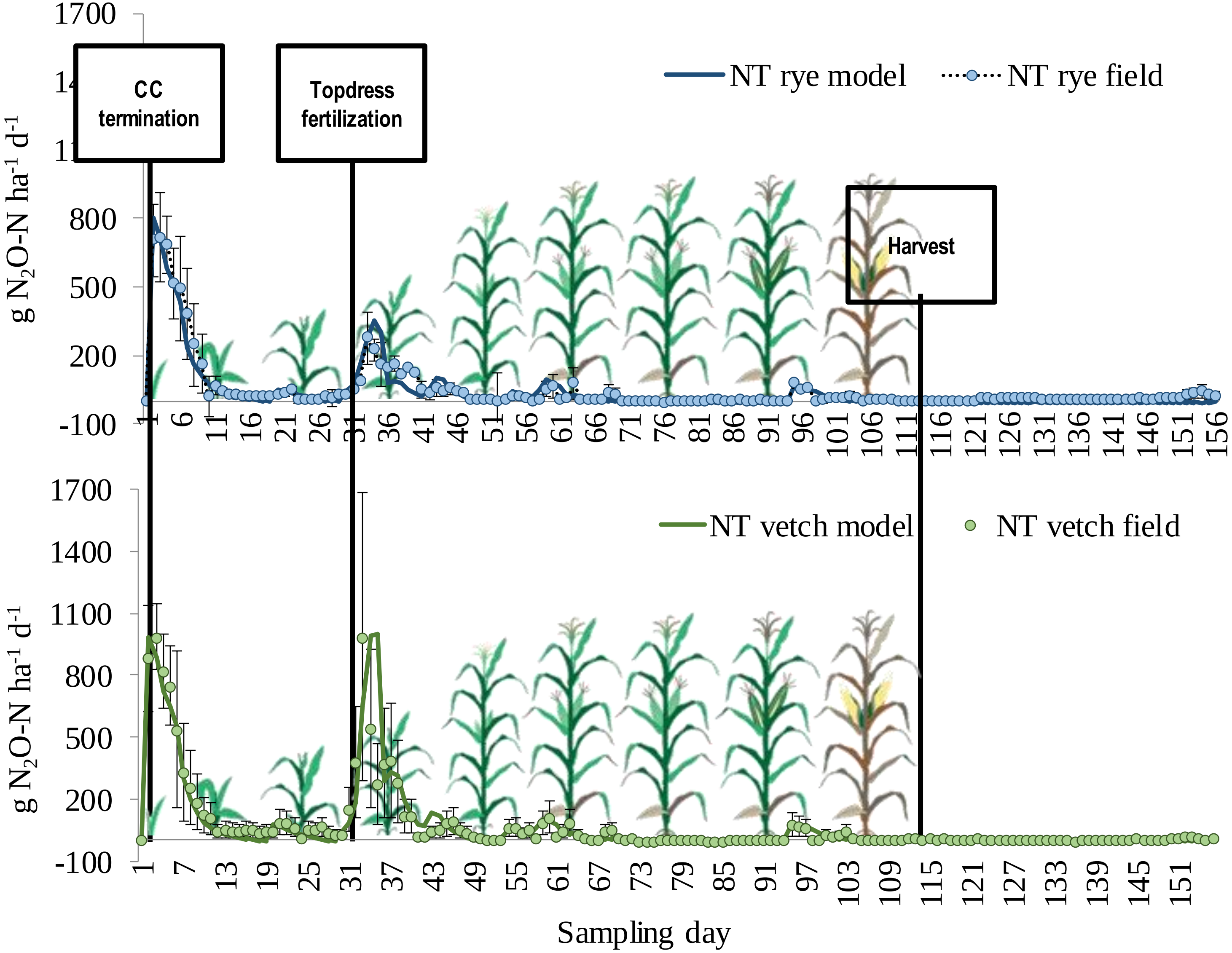
C input: 3.2-4.1 Mg C ha^{-1} yr^{-1} (12-15%) ✓

Net impact on GWP



e.g.,
↑ **C stock** by **0.5 Mg C-CO_2** ha^{-1} yr^{-1}
↑ **N_2O emissions** by **4.2 kg N-N_2O** ha^{-1} yr^{-1} ✗

N2O emissions: NT plus CCs



GOi (E)MISSION

Soil texture: silty clay

Crop seq.: maize-soybean-w.wheat

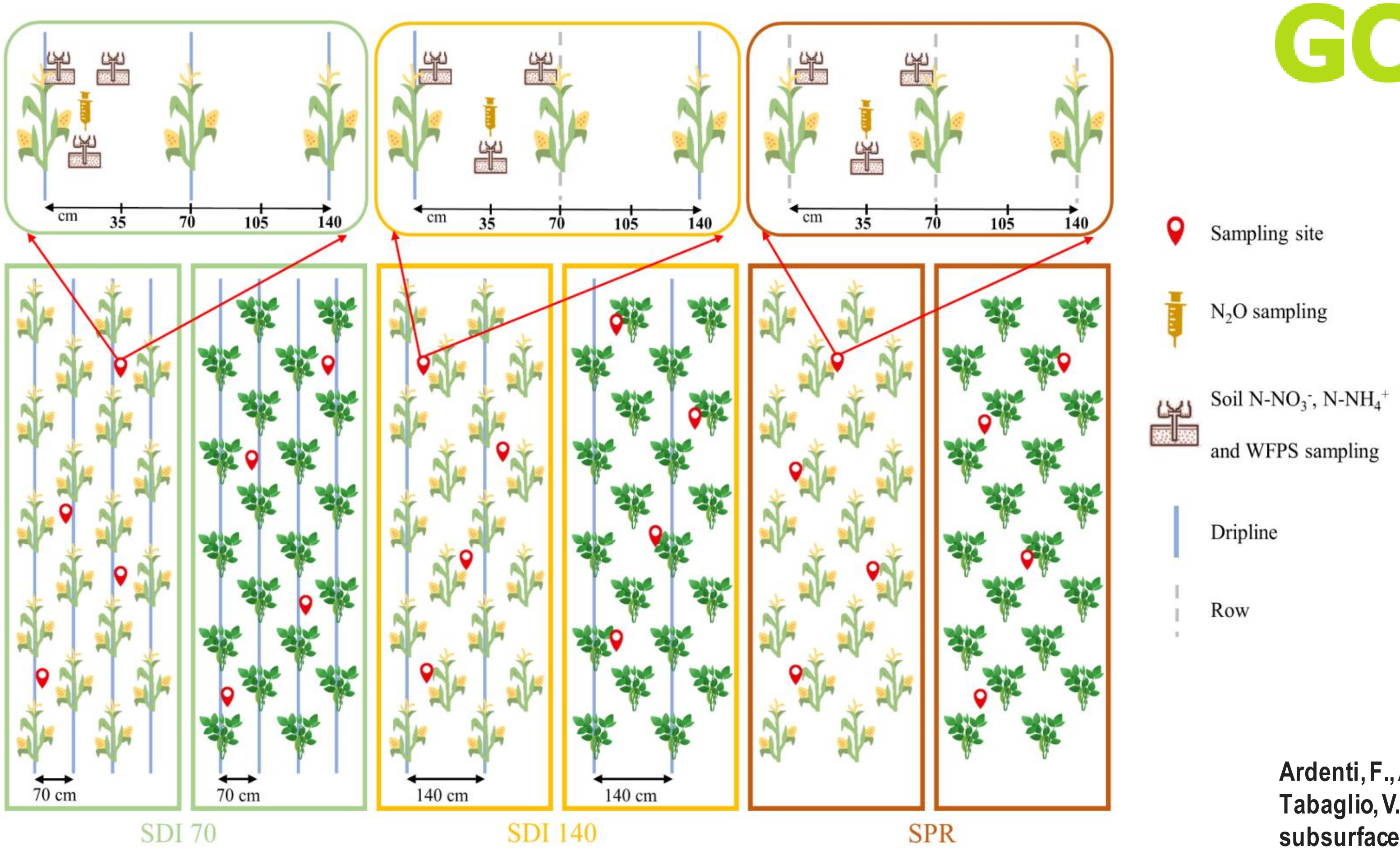
Monitoring campaign: 2017

N_2O emissions ranking:

1. **No-till + hairy vetch CC (NT-V)**
   11.12 ± 1.71 **kg N-N_2O ha^{-1} yr^{-1}**
2. **No-till + rye CC (NT-R)**
   6.94 ± 0.87 **kg N-N_2O ha^{-1} yr^{-1}**
3. Conventional tillage (CT)
   ??? 8-9 kg N-N_2O ha^{-1} yr^{-1}

Fiorini, A., Maris, S.C., Abalos, D., Amaducci, S. and Tabaglio, V., 2020. Combining no-till with rye (Secale cereale L.) cover crop mitigates nitrous oxide emissions without decreasing yield. Soil and Tillage Research, 196, p.104442.

N2O emissions: NT plus CCs and SDI



GOi Sos_Aquae

Soil texture: silty clay

Crop seq.: maize-soybean-w.wheat

Monitoring campaign: 2019-2021

N_2O emissions ranking:

1. **NT + CCs + SDI(140-cm)**
   12.9 ± 2.1 **kg N-N_2O ha^{-1} yr^{-1}**
2. **NT + CCs + SPR**
   11.2 ± 1.1 **kg N-N_2O ha^{-1} yr^{-1}**
3. **NT + CCs + SDI(70-cm)**
   7.2 ± 0.8 **kg N-N_2O ha^{-1} yr^{-1}**

Ardenti, F., Abalos, D., Capra, F., Lommi, M., Maris, S.C., Perego, A., Bertora, C., Tabaglio, V. and Fiorini, A., 2022. Matching crop row and dripline distance in subsurface drip irrigation increases yield and mitigates N2O emissions. Field Crops Research, 289, p.108732.

N2O emissions: NT plus CCs and SDI

ISA R&D

UNIVERSITÀ CATTOLICA del Sacro Cuore

GOi Sos_Aquae

Source of variation			Grain Dry Yield $(Mg\ ha^{-1})$		Total Dry Biomass $(Mg\ ha^{-1})$		Grain N-uptake $(kg\ ha^{-1})$		Total Biomass N-uptake $(kg\ ha^{-1})$		NUE (kg kg-1)		NHI (%)		NUtE $(kg\ kg^{-1})$	
Year x Irrigation x Crop																
2019	**Maize**	**SDI-70**	**11.9**	**a B**	20.8	a B	151	a B	211	a B	**31.2**	**a A**	**72**	**a A**	**56.4**	**a A**
		SDI-140	**11.9**	**a A**	22.0	a A	153	a A	239	a B	**24.9**	**b A**	**64**	**ab A**	**49.7**	**b A**
		SPR	**9.1**	**b B**	22.3	a B	146	a B	264	a A	**23.3**	**b B**	**55**	**b A**	**34.7**	**c B**
	Soybean	**SDI-70**	3.3		10.6		213		253	a A	33.9	a A	85	a A	13.0	
		SDI-140	3.6		11.3		230		269	a B	22.1	b A	86	a A	13.4	
		SPR	3.8		12.1		239		292	a A	29.4	a A	82	a B	12.9	
2020	**Maize**	**SDI-70**	**14.6**	**a A**	**26.3**	**a A**	197	a A	306	a A	**31.9**	**a A**	65	a B	**47.9**	**a B**
		SDI-140	**11.7**	**b A**	**22.6**	**b A**	178	a A	284	a A	**25.6**	**b A**	63	a A	**41.2**	**b B**
		SPR	**13.6**	**a A**	**26.4**	**a A**	189	a A	292	a A	**32.5**	**a A**	65	a A	**47.0**	**a A**
	Soybean	**SDI-70**	3.3		10.0		219		256	b A	21.0	b A	86	a A	12.9	
		SDI-140	4.4		11.5		282		321	a A	23.9	b A	89	a A	13.8	
		SPR	4.4		10.7		279		320	a A	32.4	a A	88	a A	13.8	

Ardenti, F., Abalos, D., Capra, F., Lommi, M., Maris, S.C., Perego, A., Bertora, C., Tabaglio, V. and Fiorini, A., 2022. Matching crop row and dripline distance in subsurface drip irrigation increases yield and mitigates N2O emissions. Field Crops Research, 289, p.108732.

TO BE CONTINUED…

Next steps:

- Defining “true” C sequestration potential of selected C farming practices according to specific (soil-climate) conditions
- Determining EFs of (combined) C farming practices for such specific (soil-climate) conditions
- Comprehensive evaluation of agro-ecosystem performances after C farming practices; e.g., co-benefits (or costs to be compensated?)