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INTER-SPECIFIC INTERACTIONS ON THE LIGHT, WATER AND NITROGEN AVAILABILITY IN A YOUNG POPLAR SILVOARABLE SYSTEM

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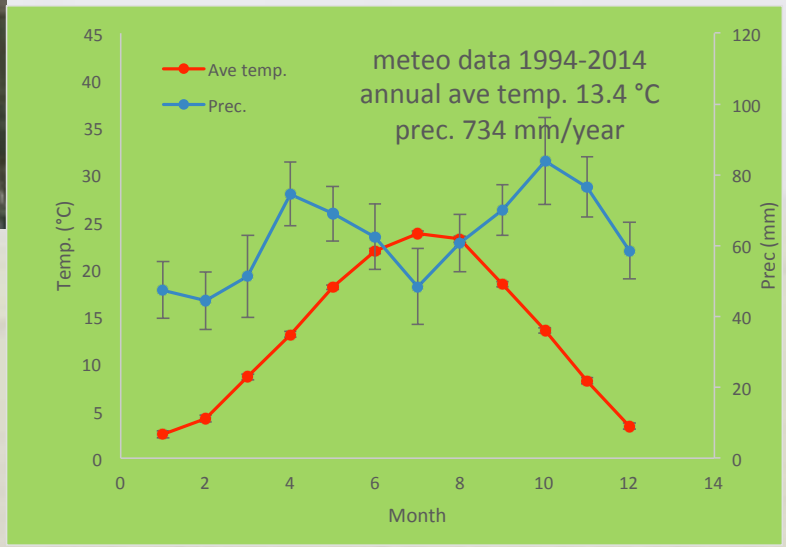
  Using Meas. 222 RDP, estab. new agroforestry systems

Exp. site, Casaria farm



Why agroforestry systems with poplar?

- **Poplar** cultivation is **declining** in Italy due to foreign imports
- Since the late '80s, rising dramatic concern for **environmental protection** of intensively cultivated areas (phyto-depuration, C seq., biodiversity…)
- Tree plantation (as **buffer strips**) in agricultural areas does protect the environment (solid runoff, N and P leaching, herbicide drift, C seq., landscape amelioration)

See: Multiple functions of buffer strips in farming areas, M. M. Borin et al., Europ. J. Agronomy 32 (2010) 103–111

Linear vs block plantation
Linear tree plantation along drainage systems (canals, streams, ditches) can be more effective for environmental protection in comparison to block plantation.

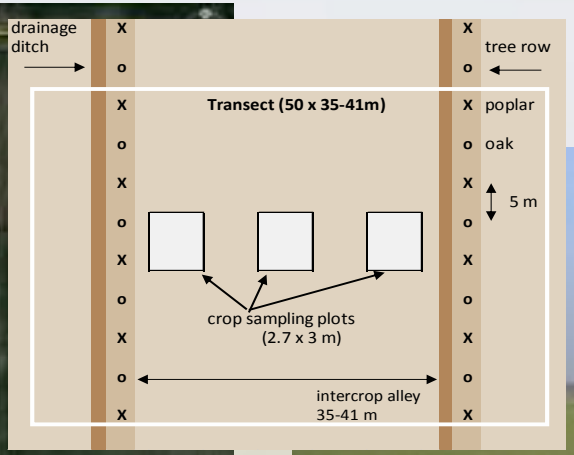
So far, most research on buffer strip systems. Almost nothing concerning alley cropping or silvoarable systems

Linear plantation

Block plantation

Experimental lay-out

Poplar (hybrid I214) and oak (Q. robur) trees planted along ditches



Measurements, 2015

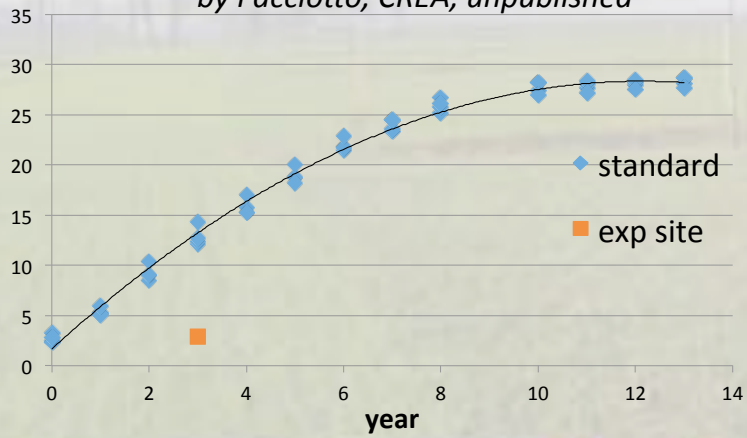
tree growth and stem form, s. beet yield, soil moisture, hemispherical photos, stable isotopes

Treatment	Treatment A: Alley Cropping Trees (Poplar and oak)	Treatment B: Alley Cropping Crop
Measurements	Meteorological data: 2004-2015	
	July ’15: Soil moisture	July ’15: Soil moisture
	July ’15: Soil and plant water stable isotopes	July ’15: Soil and plant water stable isotopes
	July ’15: Hemispherical photos	July ’15: Hemispherical photos
		Sept. ’15: Sugar beet production
	Dec. ‘15: Tree height, DBH, branching height	
	Dec. ’15: Stem Form	

Results. Tree growth (third year): poor

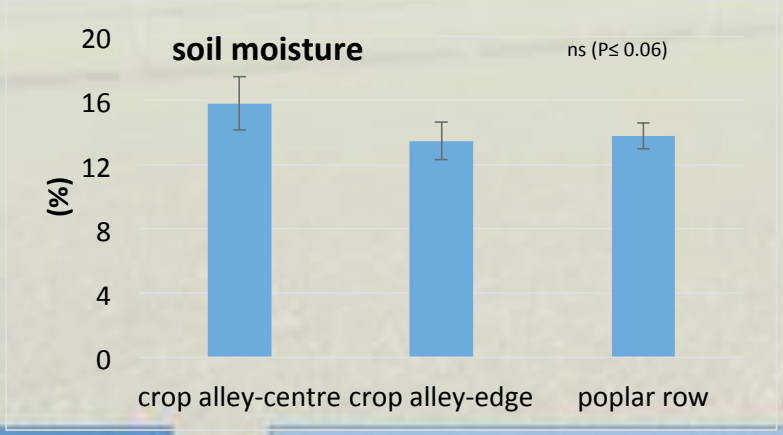
DBH (cm) Dec. 1st '15	Total H (m)	Branching Height (m)
4.3	4.43 (0.12)	2.9 (0.08)

standard H growth for poplar in Italy (m),
by Facciotto, CREA, unpublished



Why poor tree growth?

- Soil preparation along tree row vs intercrop alley
- Quality of planting material
- Tree capability to reach the groundwater
- Wide tree spacing with microclimate limitations



Good Stem form and wood quality

Index of Stem Straightness:

1 = completely vertical and straight

2 = roughly vertical and straight

3 = roughly vertical, 1–2 bends

4 = not vertical, 1–2 bends

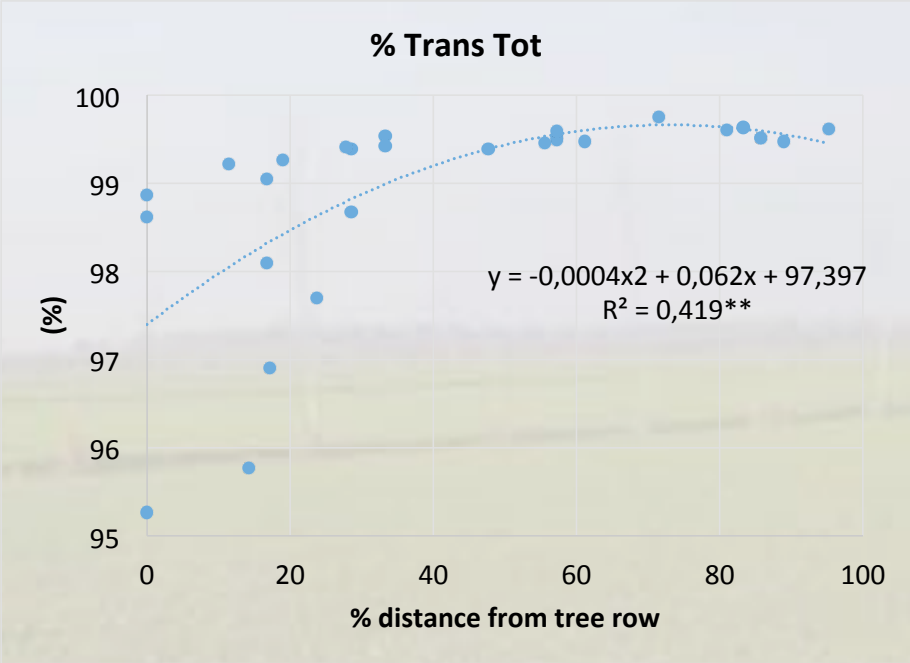
5 = not vertical and greater than two bends

6 = very crooked (not vertical and greater than three bends)

By Barrett and Mullin (1968), re-adapted by Mwase et al. (2008)

Sugar beet yield and solar radiation

Plot	Root Dry Yield (Mg ha^{-1})	Sugar rate (%)
	(mean and ± sem)	
Alley edge-Est	14.4 (0.67)	15.9 (0.249) ns
Alley edge-West	16.2 (1.19)	15.92 (0.297)
Alley Centre	12.6 (0.9)	15.17 (0.387)
ANOVA P value		
Transect	0.166	0.007
Plot	0.324	0.097



Isotopes

The same chemical element differing in the number of neutrons.

Example: nuclea of the three hydrogen isotopes

Hydrogen	Deuterium	Trithium
		
1 proton	1 proton	1 proton
	1 neutron	2 neutron

Element	*Isotope*	*Abundance (%)*
Hydrogen	^{1}H	99.985
	^{2}H	0.015
Carbon	^{12}C	98.89
	^{13}C	1.11
Nitrogen	^{14}N	99.63
	^{15}N	0.37
Oxygen	^{16}O	99.759
	^{17}O	0.037
	^{18}O	0.204
Sulfur	^{32}S	95.00
	^{33}S	0.76
	^{34}S	4.22
	^{36}S	0.014

Average terrestrial abundances of the stable isotopes of major elements of interest in ecological studies

Isotopic fractionations

Equilibrium or thermodynamic effects: partial separation of isotopes between two or more substances in chemical equilibrium

Kinetic effects are functions of the change of the rate constants of chemical reactions, due to the isotopic identity of a reactant

Carbon stable isotopes

natural abundances

^{12}C 98.9% ^{13}C 1.1%

isotope ratio: $R = {}^{13}C/{}^{12}C$

carbon isotope composition: $\delta^{13}C = (R_s/R_{st})-1$

carbon isotope discrimination Δ

$\Delta = (\delta_{air}-\delta_{plant})/(1+\delta_{plant})$

$\Delta = a+(b-a)p_i/p_a$

water-use efficiency: $WUE = p_a(1- p_i/p_a)/1.6VPD$

$WUE = f(b-\Delta)$

Oxygen stable isotopes

natural abundances

^{16}O ~ 99.76% ^{17}O ~ 0.04% ^{18}O ~ 0.20%

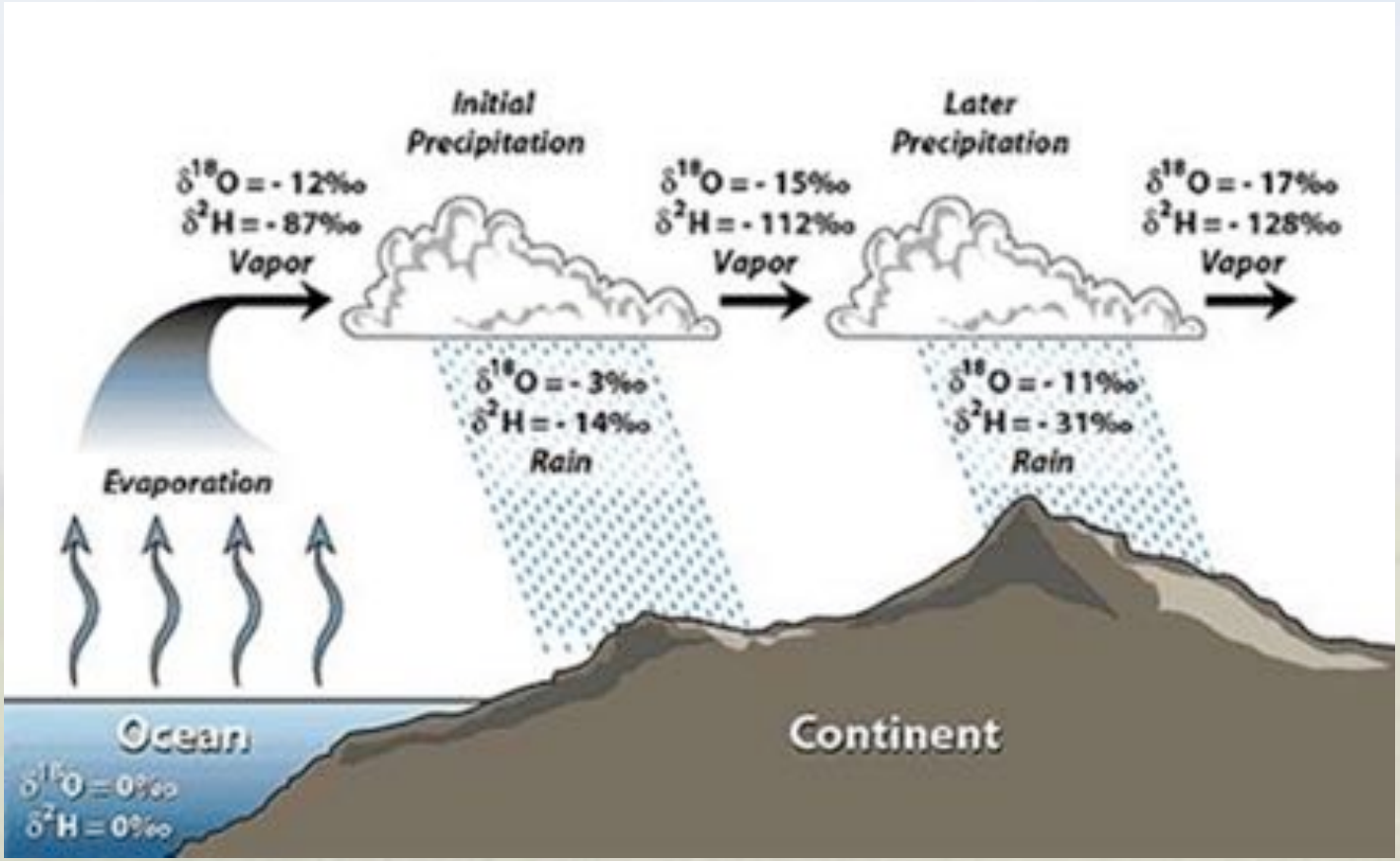
isotope ratio: $R = {}^{18}O/{}^{16}O$

isotope composition: $\delta^{18}O = R_{sample}/R_{standard} - 1$

isotope discrimination: $\Delta^{18}O = (\delta_{sample}-\delta_{source})/(1+\delta_{source})$

international standard

VSMOW

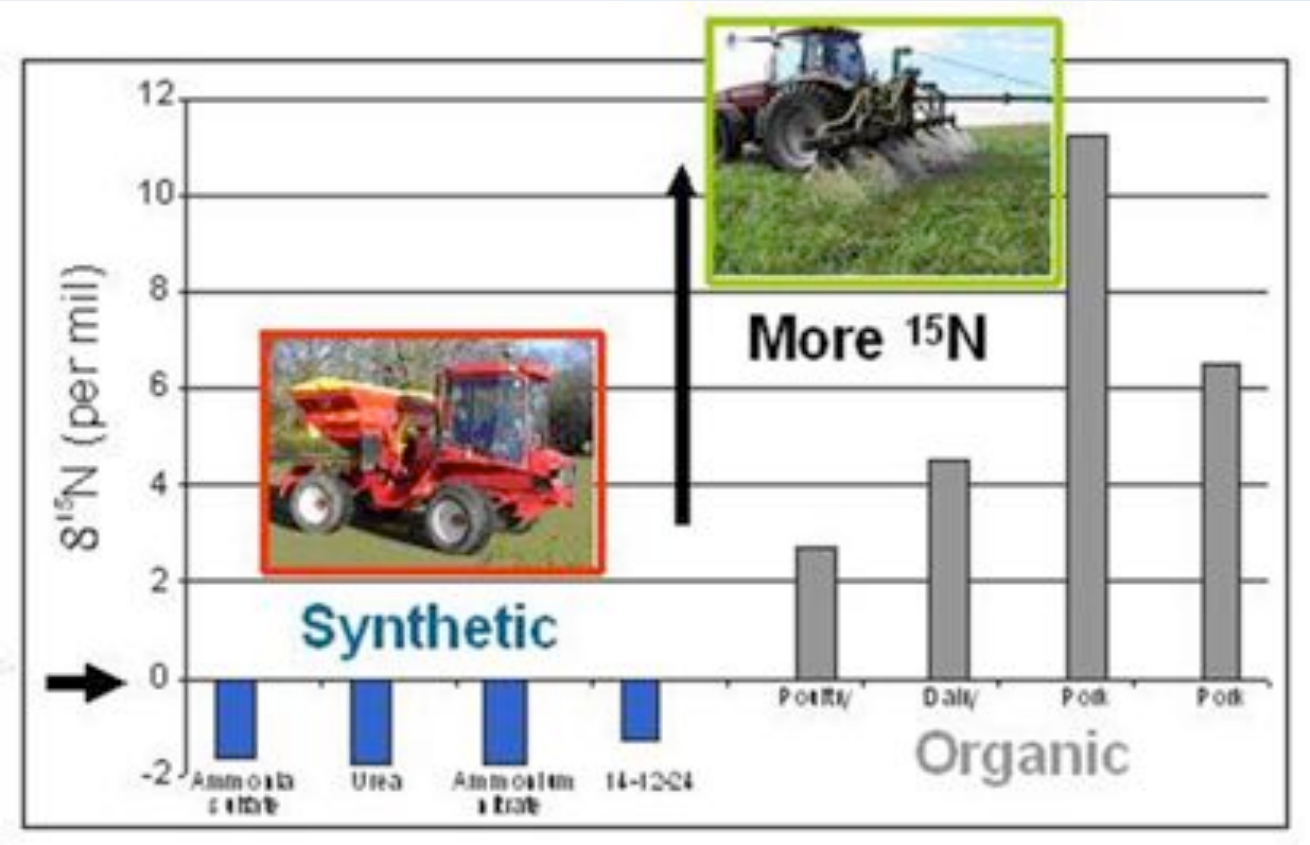

Initial
Precipitation
Later
Precipitation
δ18O = - 12‰
δ2H = - 87‰
Vapor
δ18O = - 15‰
δ2H = - 112‰
Vapor
δ18O = - 17‰
δ2H = - 128‰
Vapor
δ18O = - 3‰
δ2H = - 14‰
Rain
δ18O = - 11‰
δ2H = - 31‰
Rain
Evaporation
Ocean
δ18O = 0‰
δ2H = 0‰
Continent

Nitrogen stable isotopes

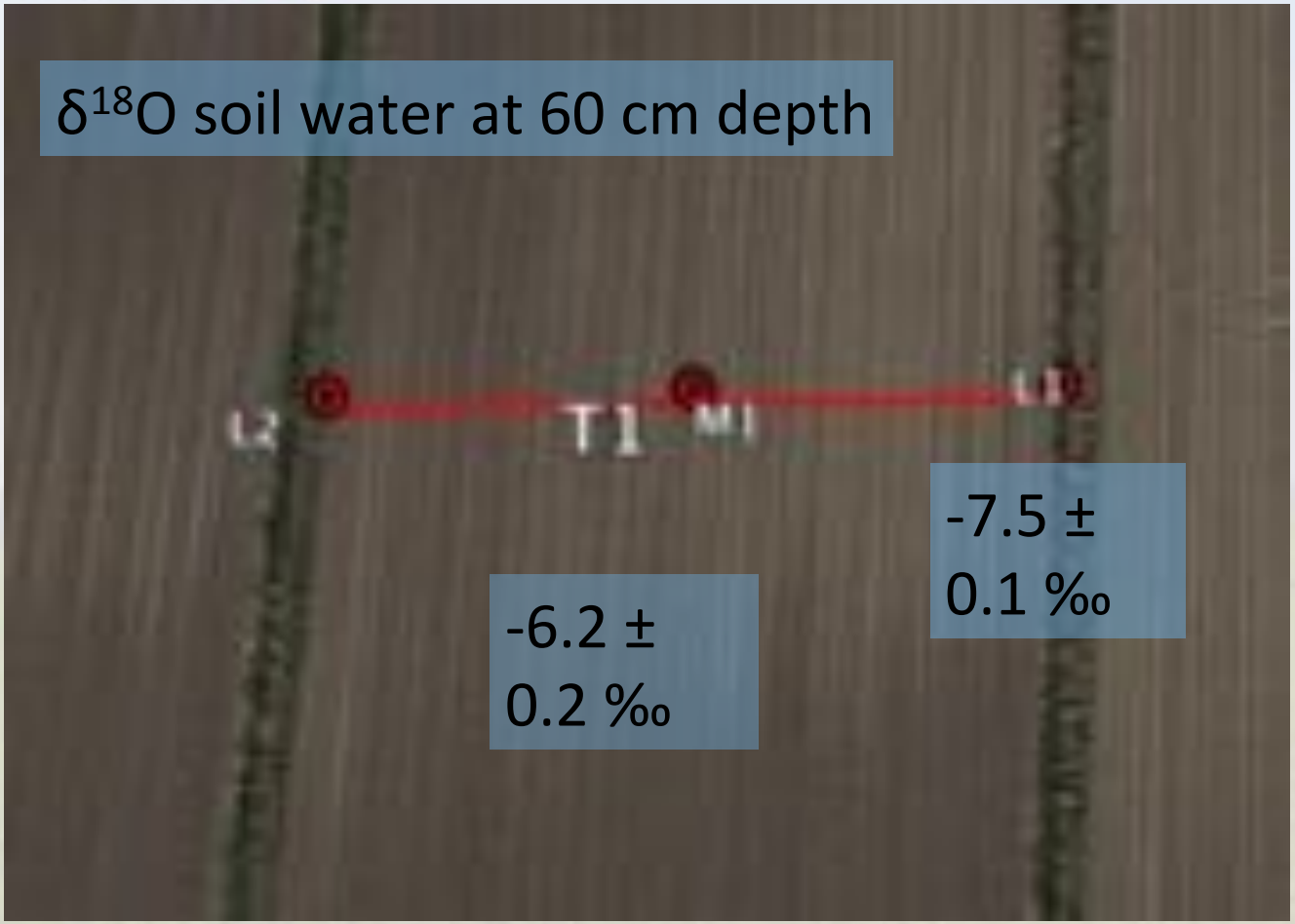
Natural abundances (atom %)

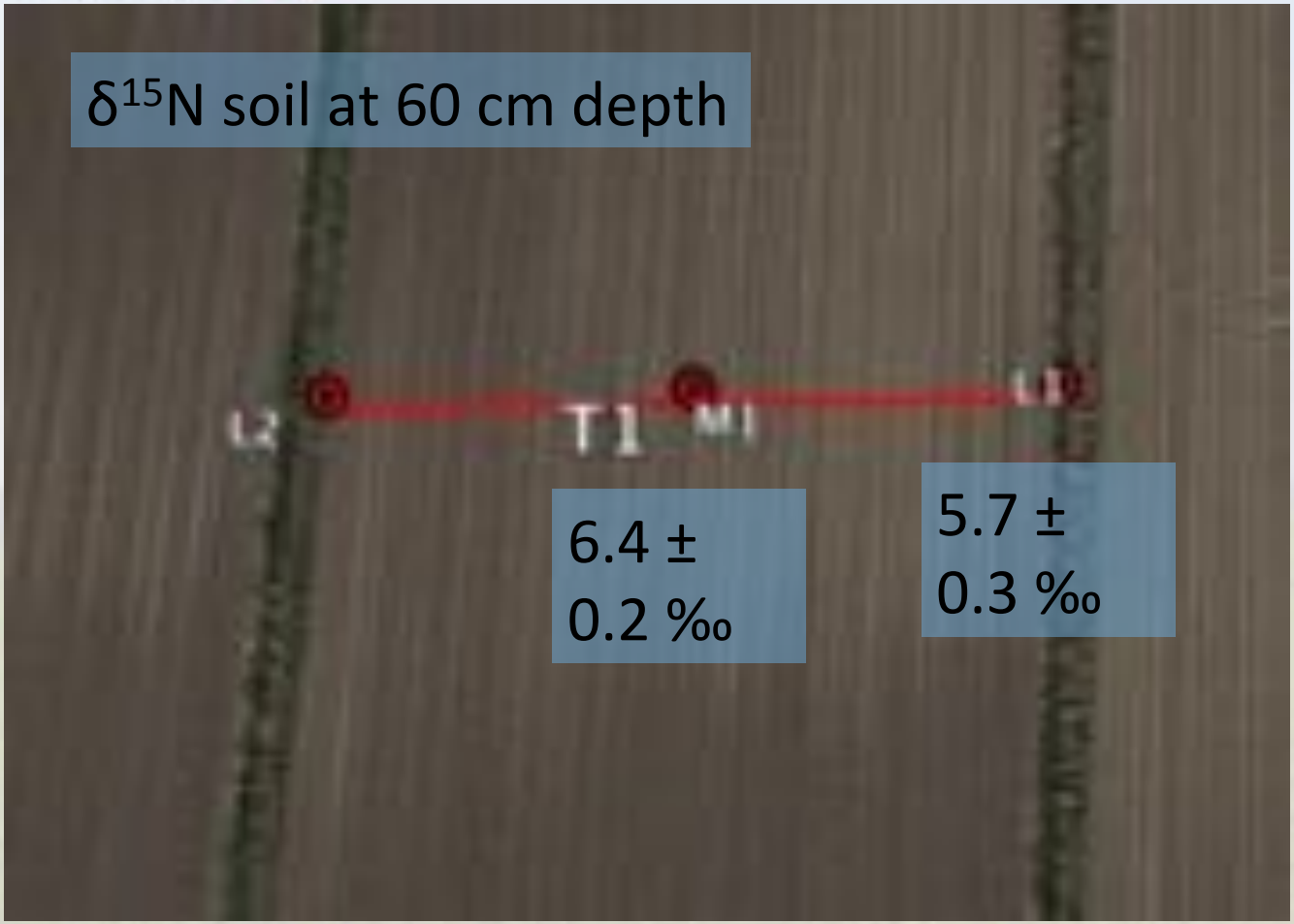
^{14}N 99.632 % ^{15}N 0.368 %

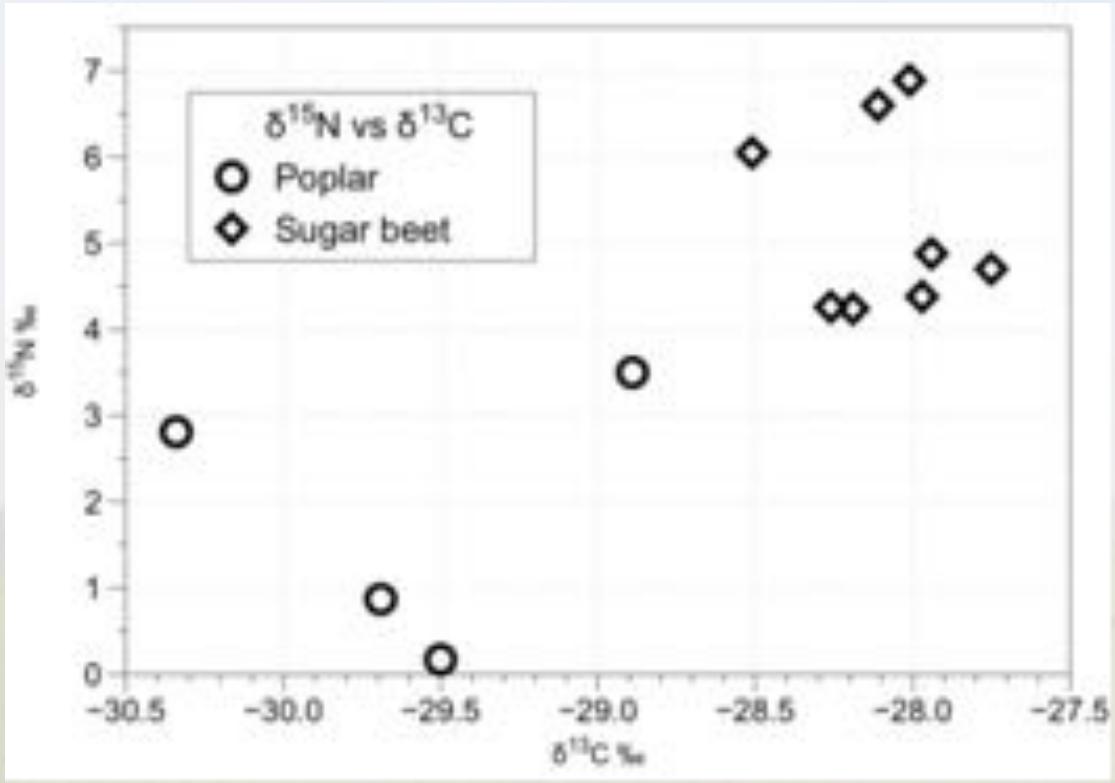
- Natural ^{15}N levels in biological materials typically range from ~-5 ‰ to ~+10 ‰
- Atmospheric N is isotopically lighter than plant tissues
- Microbes discriminate against the light isotope during decomposition
- Non-nitrogen-fixing plants are isotopically heavier than nitrogen-fixing plants


12
10
8
6
4
2
0
-2
δ15N (per mil)
More 15N
Synthetic
Organic
Urea
Poultry
Pork


T3
T1
T2
Google earth
N


δ18O soil water at 60 cm depth
L2
T1
M1
-7.5 ± 0.1 ‰
-6.2 ± 0.2 ‰


δ15N soil at 60 cm depth
L2
T1
M1
L1
6.4 ± 0.2 ‰
5.7 ± 0.3 ‰



Nitrogen isotope composition ($\delta^{15}N$) vs carbon isotope composition ($\delta^{13}C$) in poplar (circles) and sugar beet (diamond) leaves.

Conclusion

- The system is in its early stage of development
- Trees longer rotatation is currenly expected than in conventional block plantation
- Intrecrop yield is currently not affected by trees
- Tree roots are actively incercepting N leaching
- Different soil hydrology conditions indicated by $\delta^{18}O$ observations
- Inter-specific diversity in water-use efficiency and nitrogen nutrition suggested by $\delta^{13}C$ and $\delta^{15}N$ analyses