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THE KILL DATE AS A MANAGEMENT TOOL TO INCREASE COVER CROPS BENEFITS IN WATER QUALITY & NITROGEN RECYCLING

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AGRÓNOMOS ETSIAUPM
We Engineer Life, Food and Environment

- Introduction
- Materials & Methods
- Results
- Conclusions

COVER CROP

Environmental services

- ❖Water infiltration increase
- ❖Recycle Nitrogen
- ❖Nutrient supply
- ❖Soil organic carbon increase
- ❖Soil erosion reduction
- ❖Weed control

.....

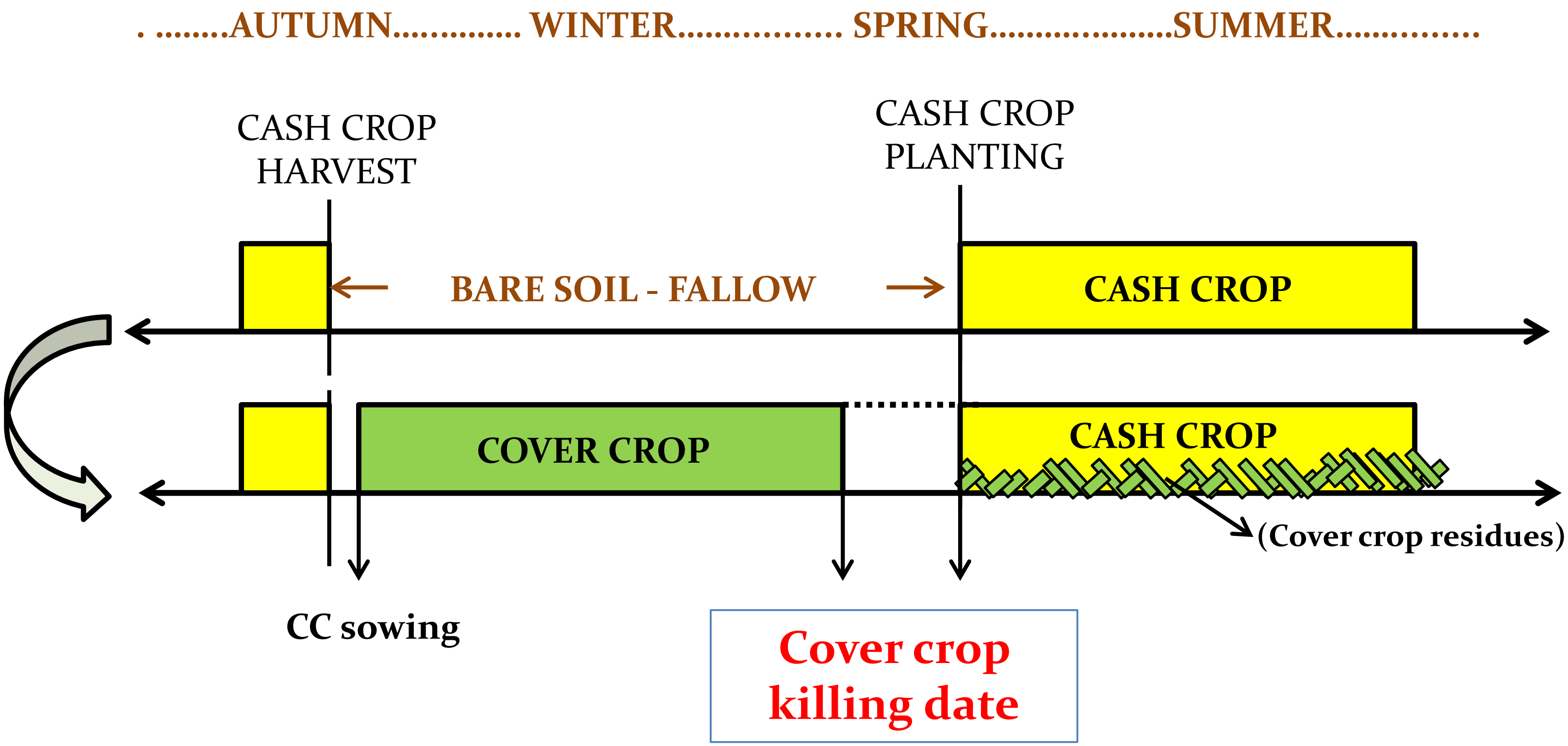
❖**COMPETENCE WITH CASH CROP**

MANAGEMENT CHALLENGE!

… in interrows spaces…

...in a rotation, substituting fallow period... ✓

INTRODUCTION



Effect on:

-Water and N absorbed

- Mulch quantity & quality

- N and water cycles

NITROGEN AND WATER COMPETITION

OBJECTIVES

- **Combined study** of cover crop growth, ground cover and water and N dynamics

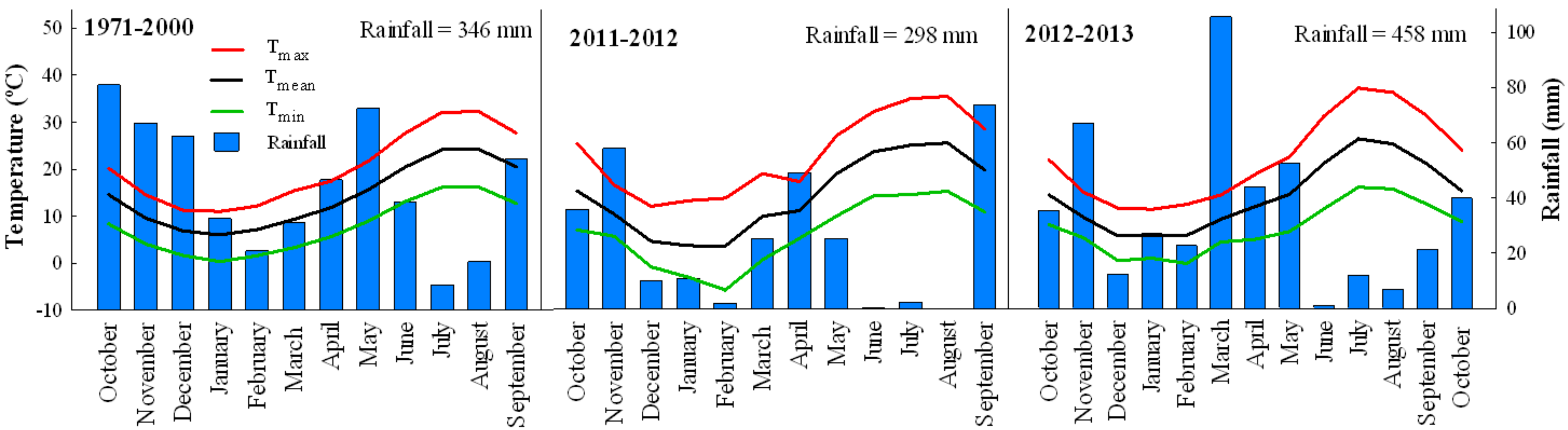
- Effect of the kill date on:
  - Growth and N content of cover crop (CC)
  - Cover crop chemical composition and residue quality
  - **Soil organic N dynamics and potentially mineralizable N**
  - **The soil water content.**

MATERIALS & METHODS

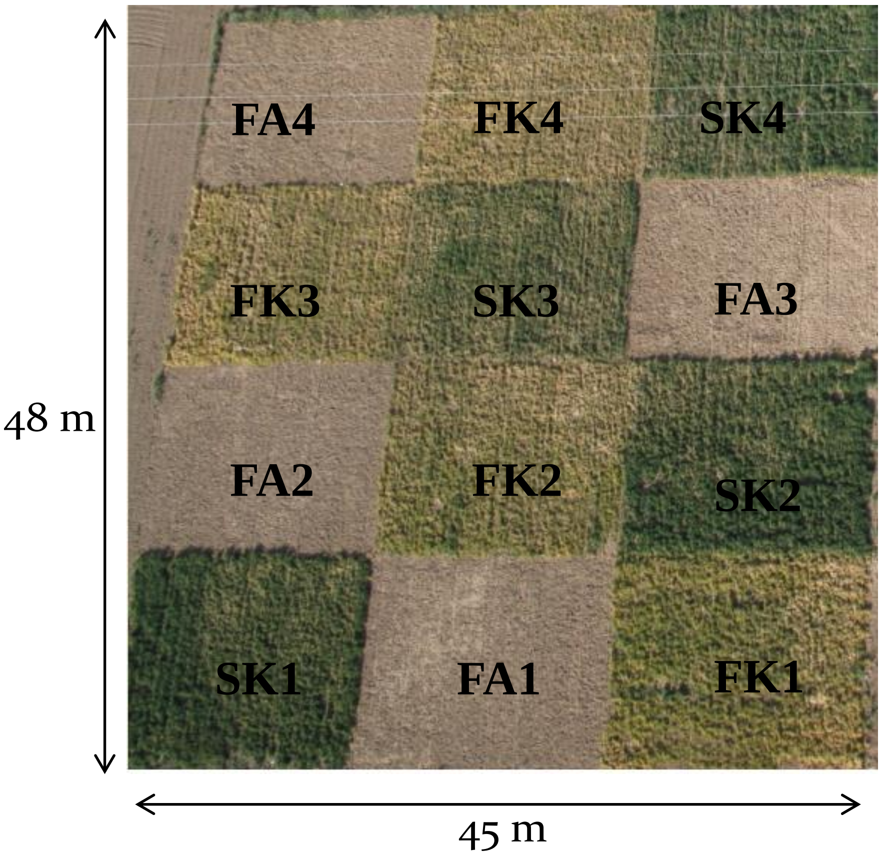
- *La Chimenea* field station
  Aranjuez, Madrid (40°03′N, 03°31′W)

- *Typic Calcixerept soil*

- Climate: semiarid Mediterranean



Experimental design



(*) Killing method → glyphosate (2%) + shredder

Two-year experiment

Treatments

- FA – fallow
- FK- first kill
- SK- second kill

30% barley + 70 % vetch

	2011-2012	2012-2013
Sowing	October 6th	October 8th
FK date	**March 13th**	**March 14th**
SK date	**April 9th**	**April 10th**

Hypothetical cash crop planting date : **April 30th**

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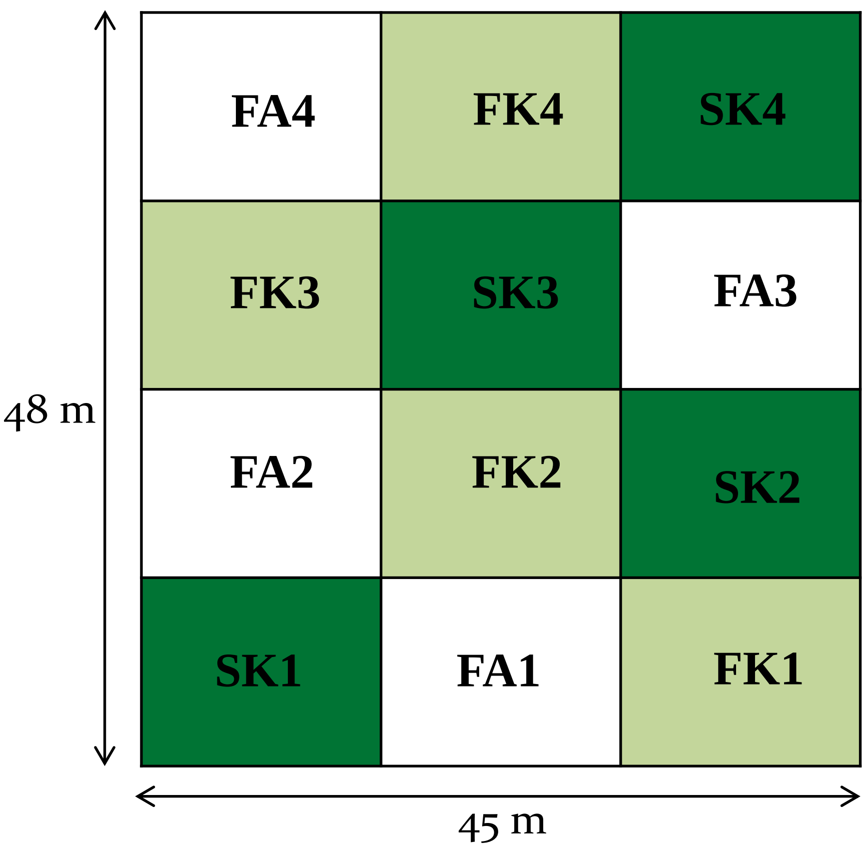

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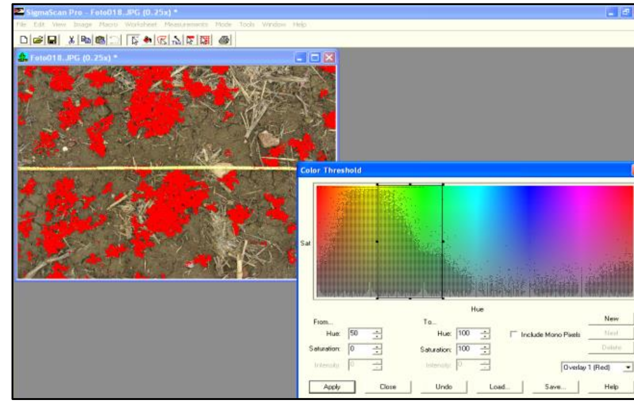
Variables measured

- Ground cover (%)
- Aerial biomass
- %C , %N
- Residue quality
- Atmospheric N fixation
- Soil inorganic N content
- Soil N mineralization
- Soil water content



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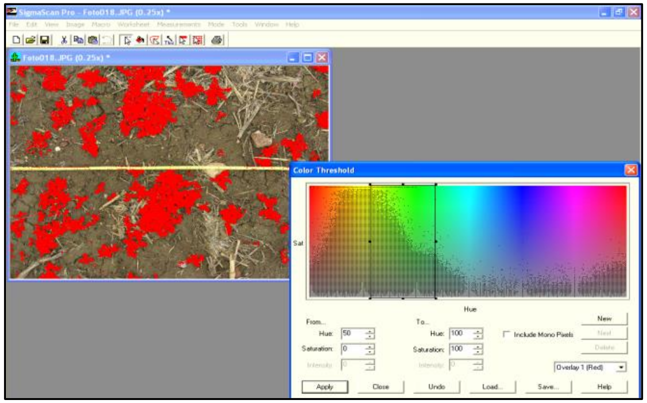

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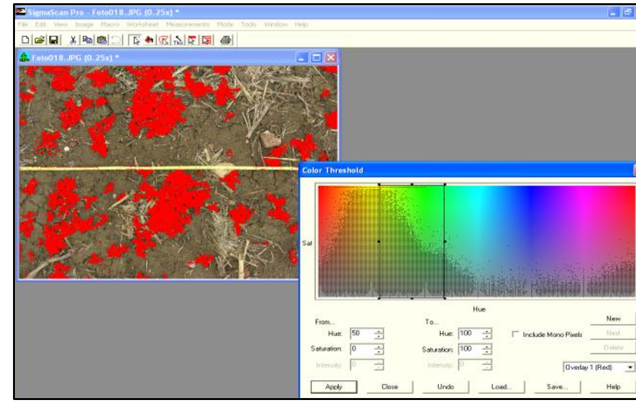

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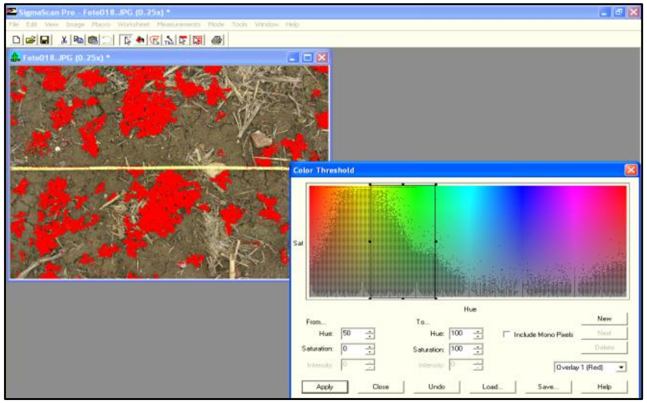
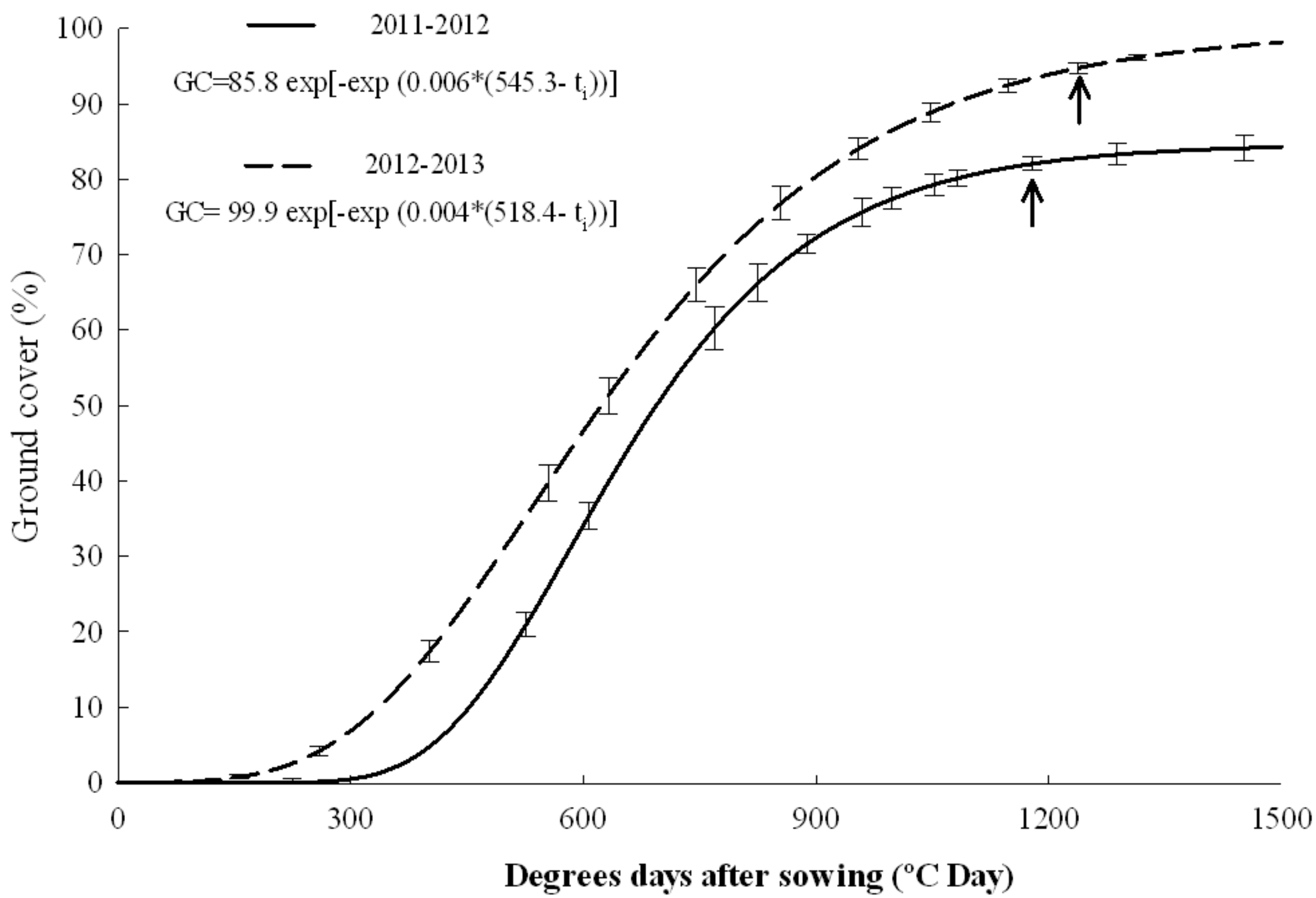
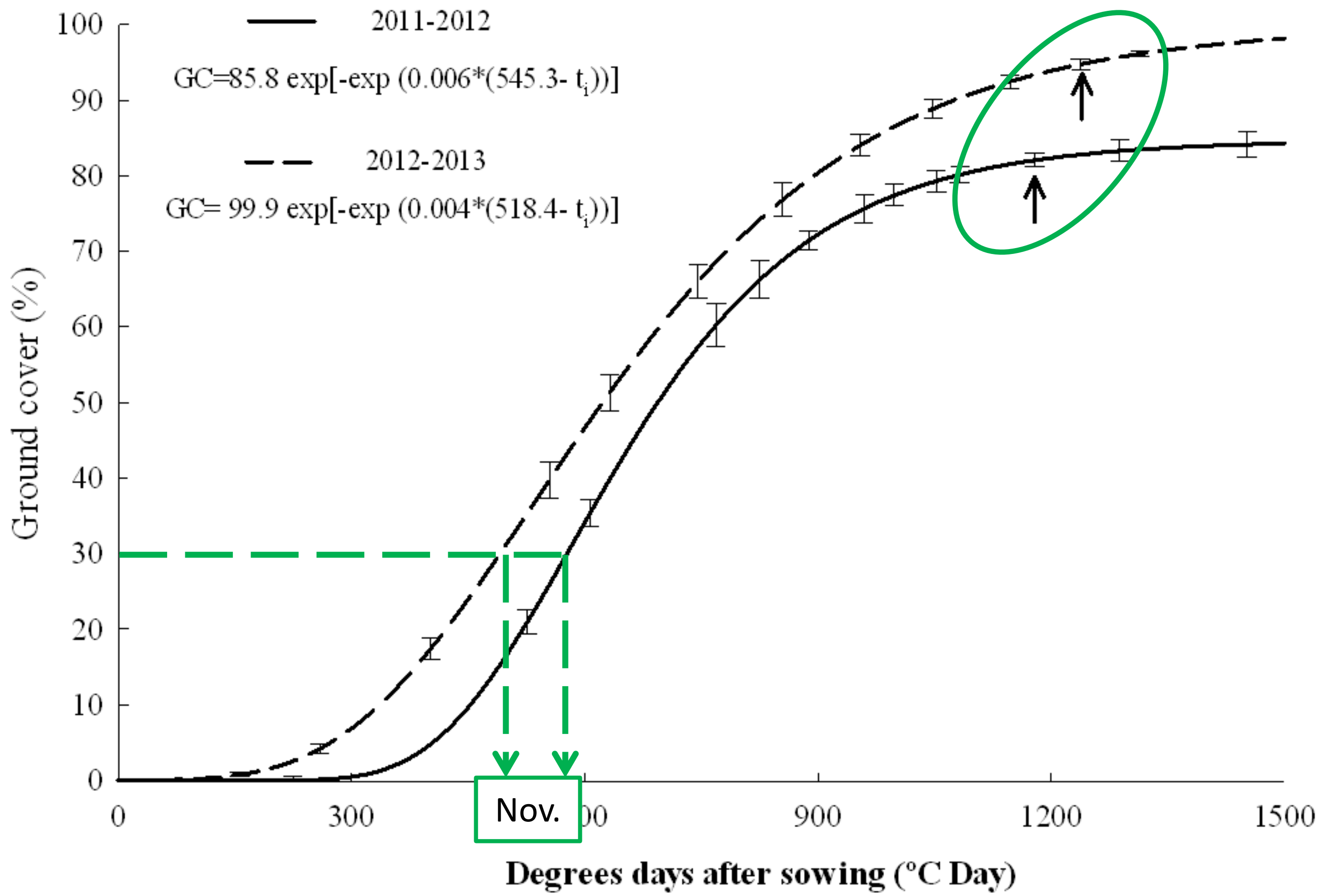


Cover crop ground cover



- 80% ground cover attained the first date
- To delay the CC kill date did not increment ground cover

Cover crop ground cover



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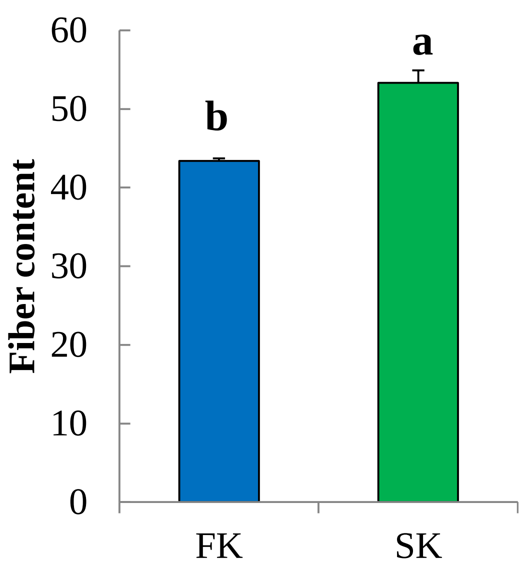
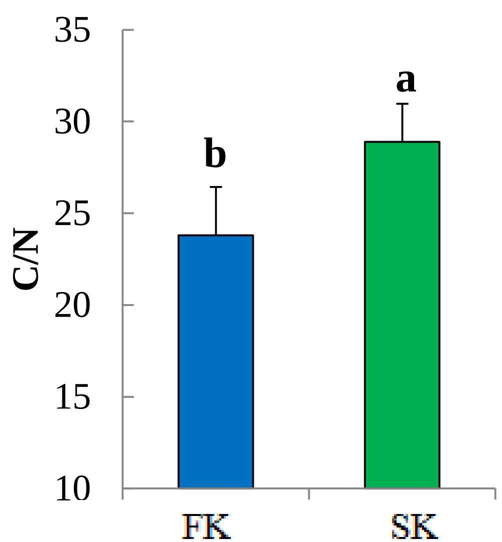
Cover crop growth & residue properties

	2011-2012		
	Biomass (kg ha^{-1})	**N content (kg ha^{-1})**	**Residue left (kg ha^{-1})**
First kill date	4606.4 b	124.2 (10)	966.1 a
Second kill date	6614.6 a	155.1 (12.9)	2214.4 b





- Kill date affected aerial biomass
- To delay the kill date provided

⇩

more residues

⇩

resistent to decomposition

(Alonso-Ayuso et al. 2014, Plos One)

RESULTS

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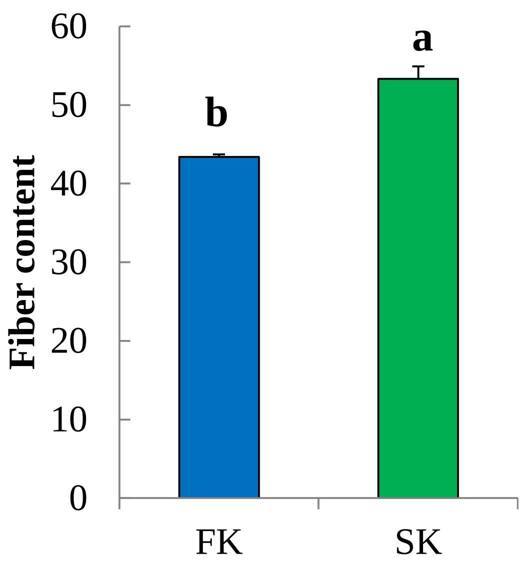

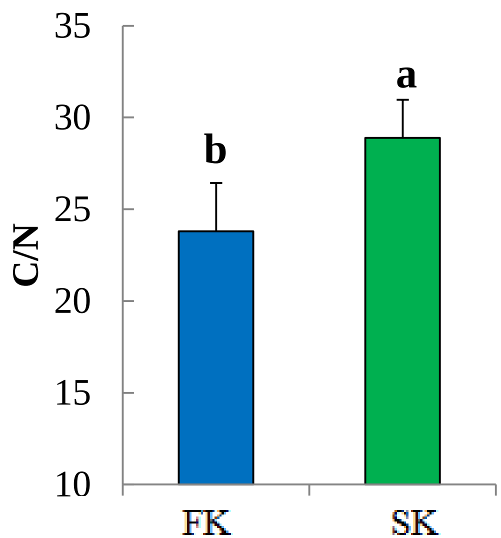

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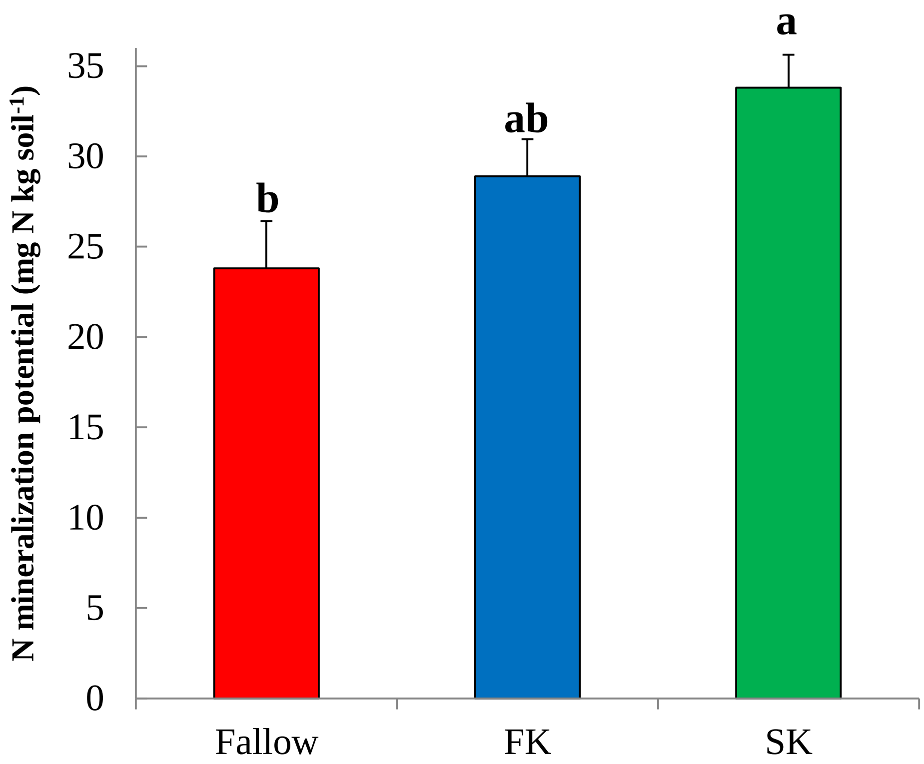
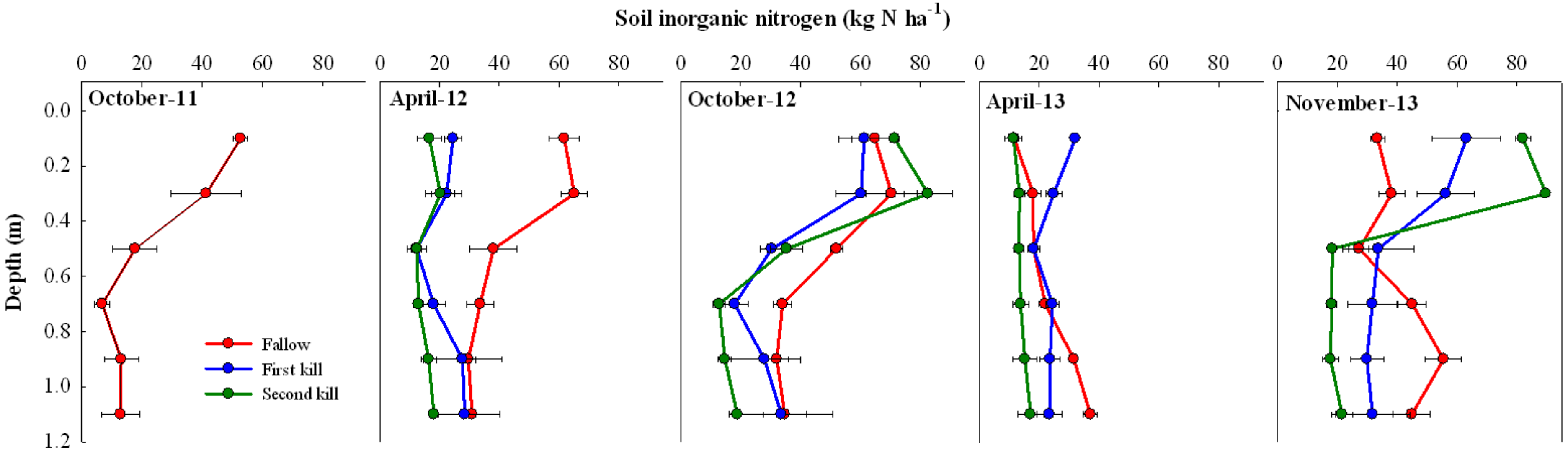
N mineralization potential



➢CC contribute to **the enhancement of labile soil organic pools** by

- Root exudation & root turnover
- Residue decomposition

Soil inorganic nitrogen



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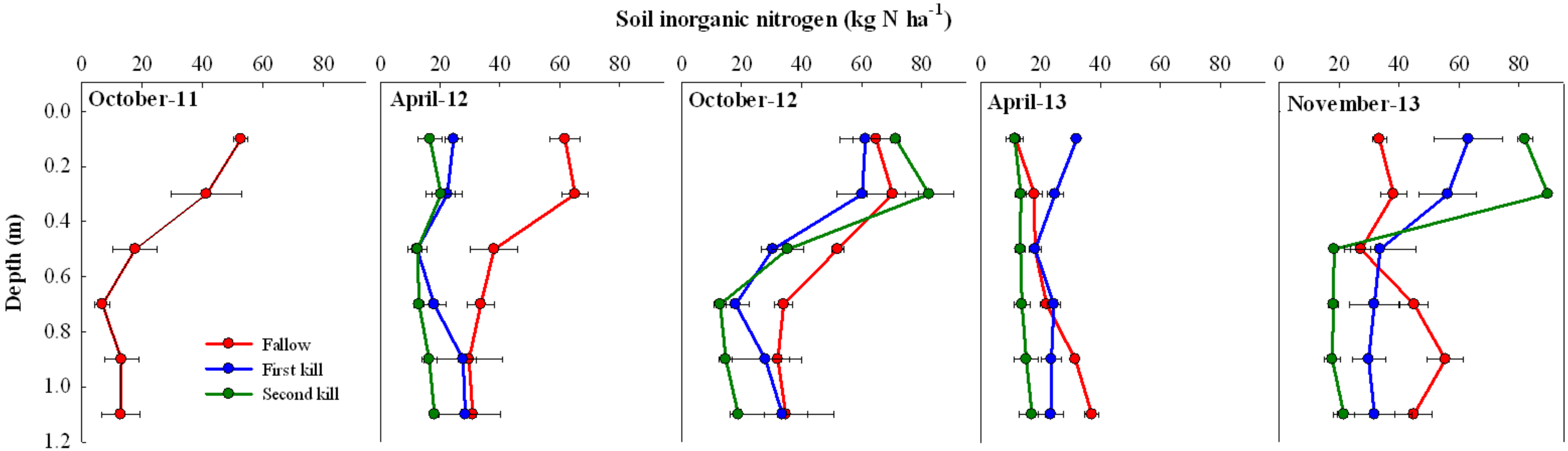
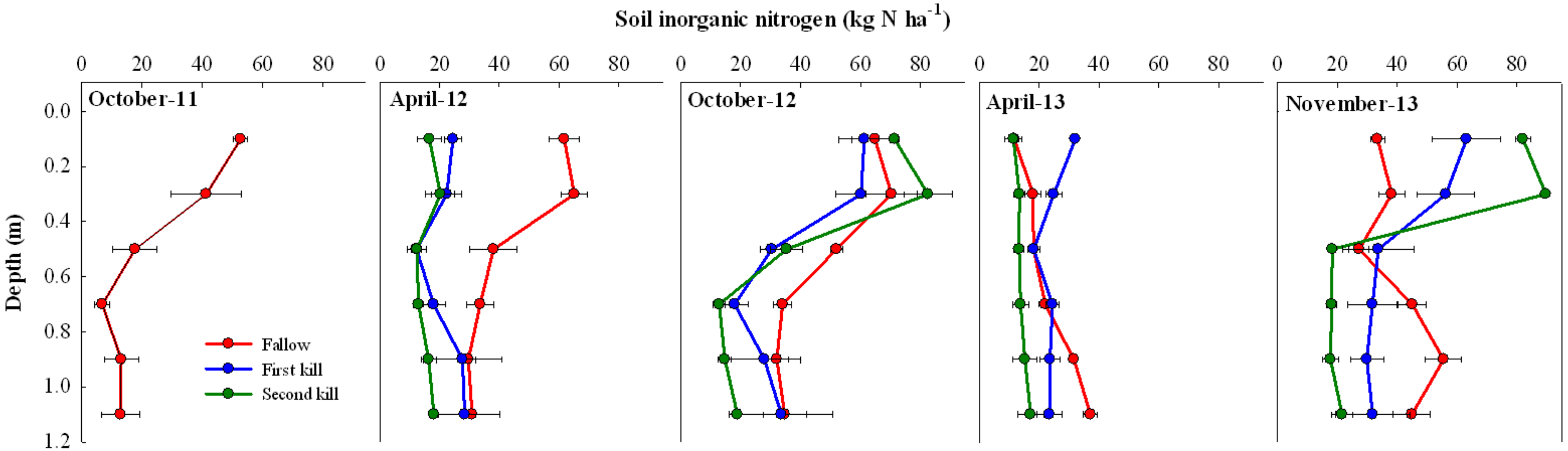
RESULTS

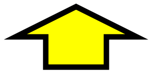
Soil inorganic nitrogen



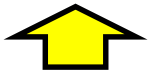
Sampling prior to experiment starting

Soil inorganic nitrogen





Sampling after cover crop killing in Spring



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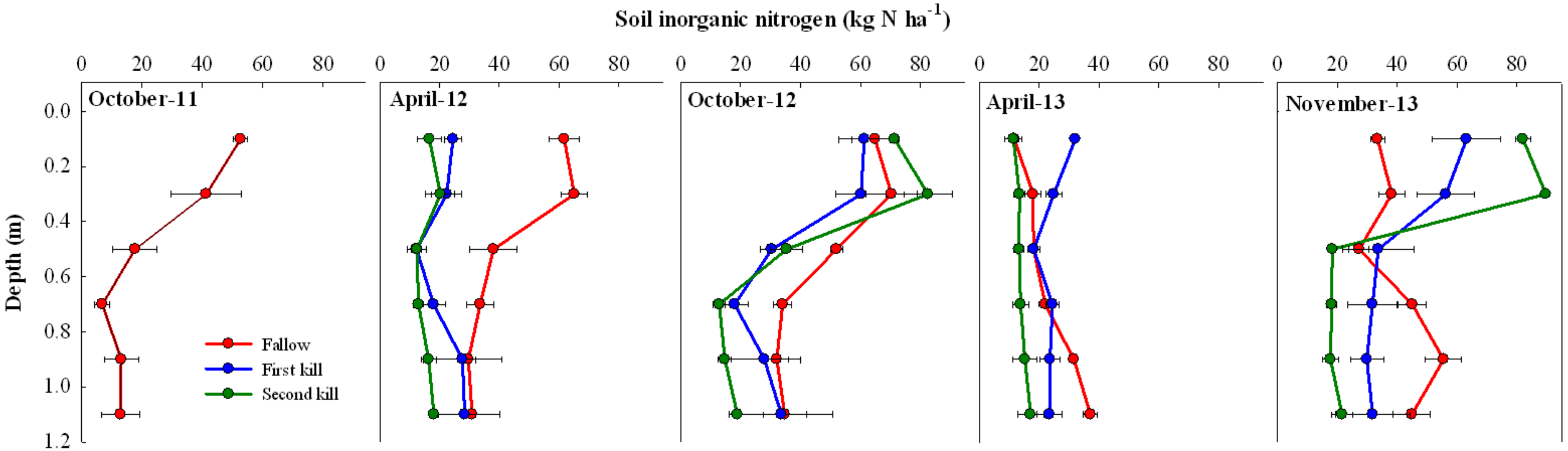


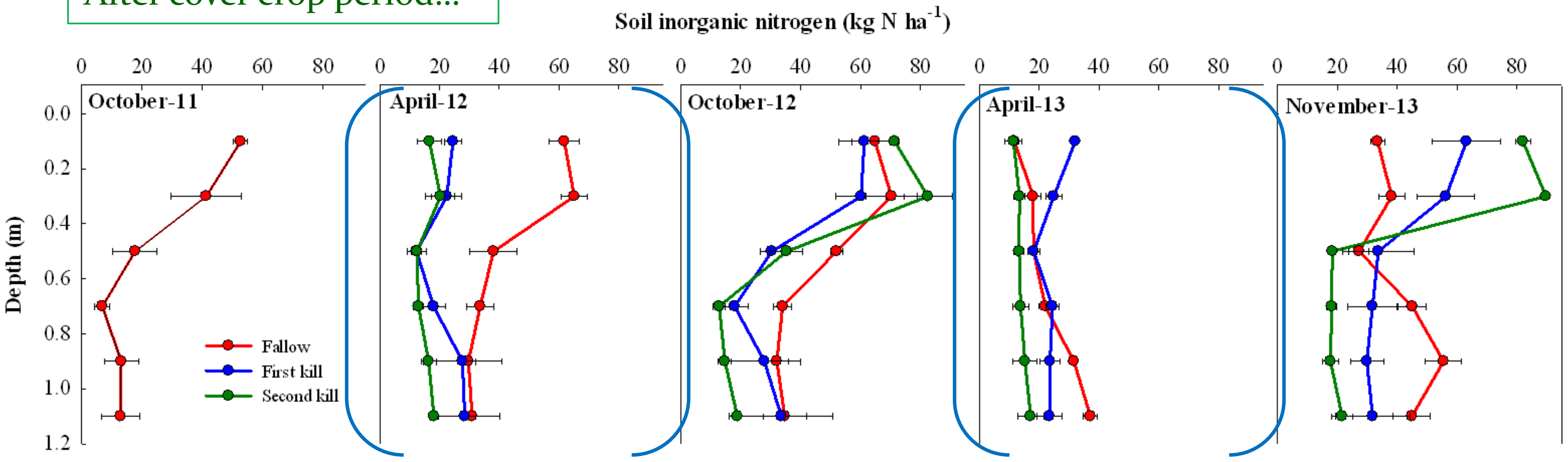
Sampling after mulch period

Sampling after mulch period

RESULTS

Soil inorganic nitrogen

After cover crop period...



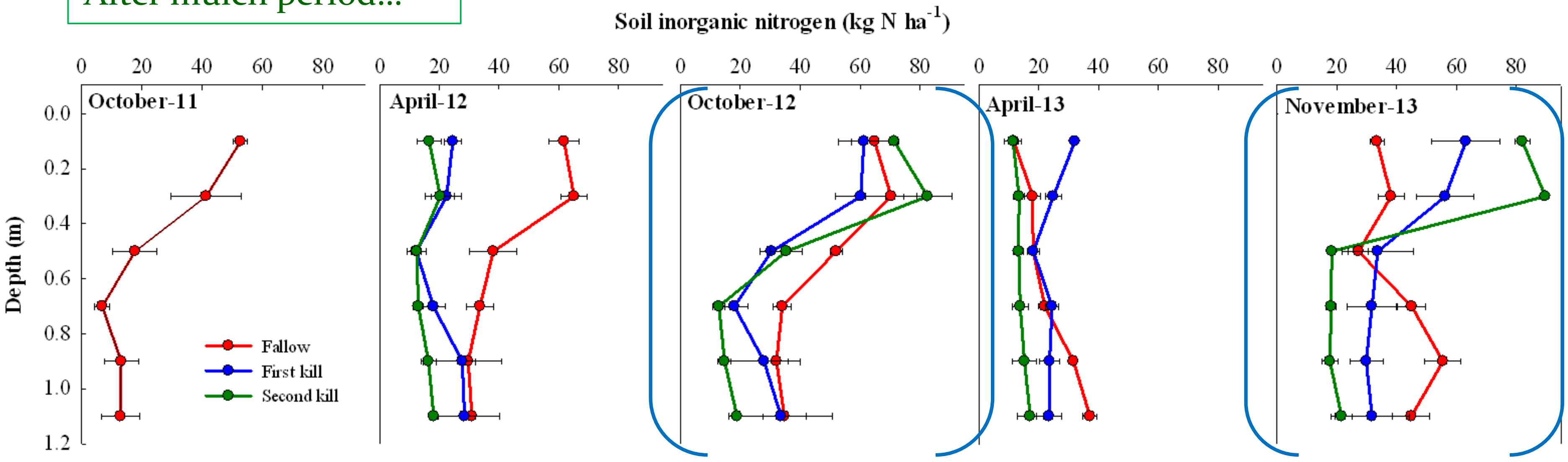
- Cover crops → **N leaching risk decrease**
- Early kill date → more time for residue decomposition before cash crop sowing
- Later kill date → **N pre-emptive competition**

(Alonso-Ayuso et al. 2014, Plos One)

RESULTS

Soil inorganic nitrogen

After mulch period…

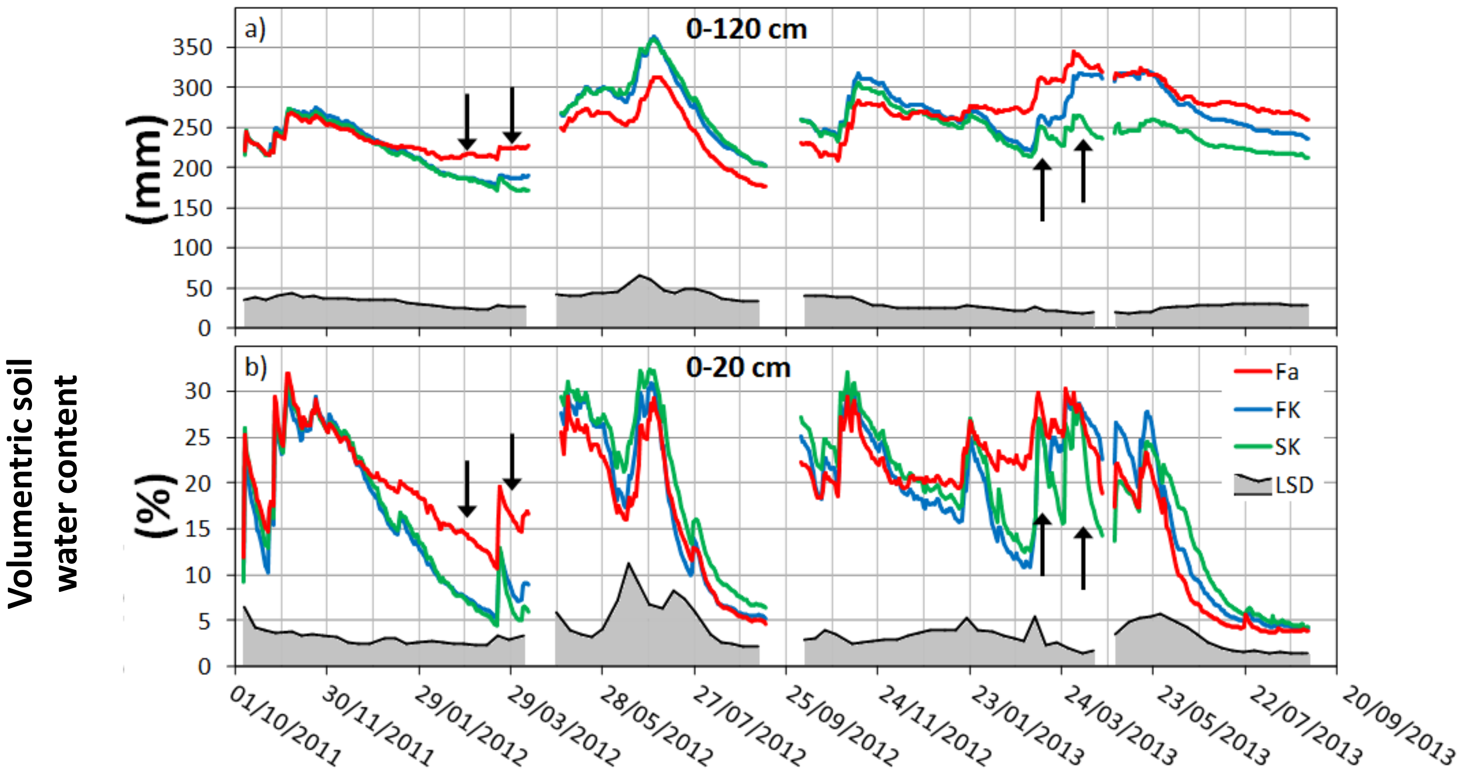


- Cover crops → **Nitrogen recycling effect**

→ **Leaching risk decrease**

(Alonso-Ayuso et al. 2014, Plos One)

Soil water content



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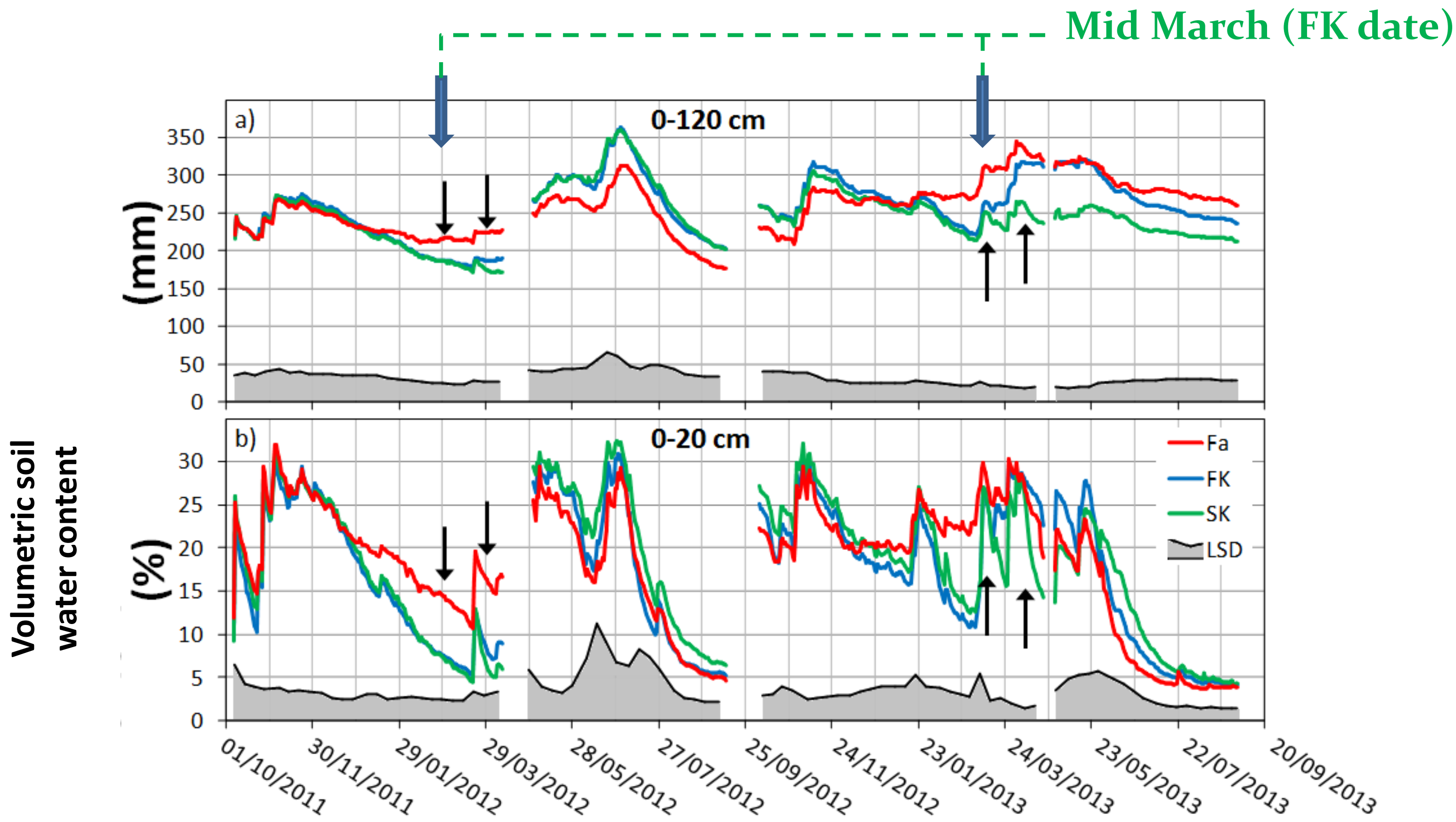


- Cover crops water extraction → in March, fallow soil water content was greater.

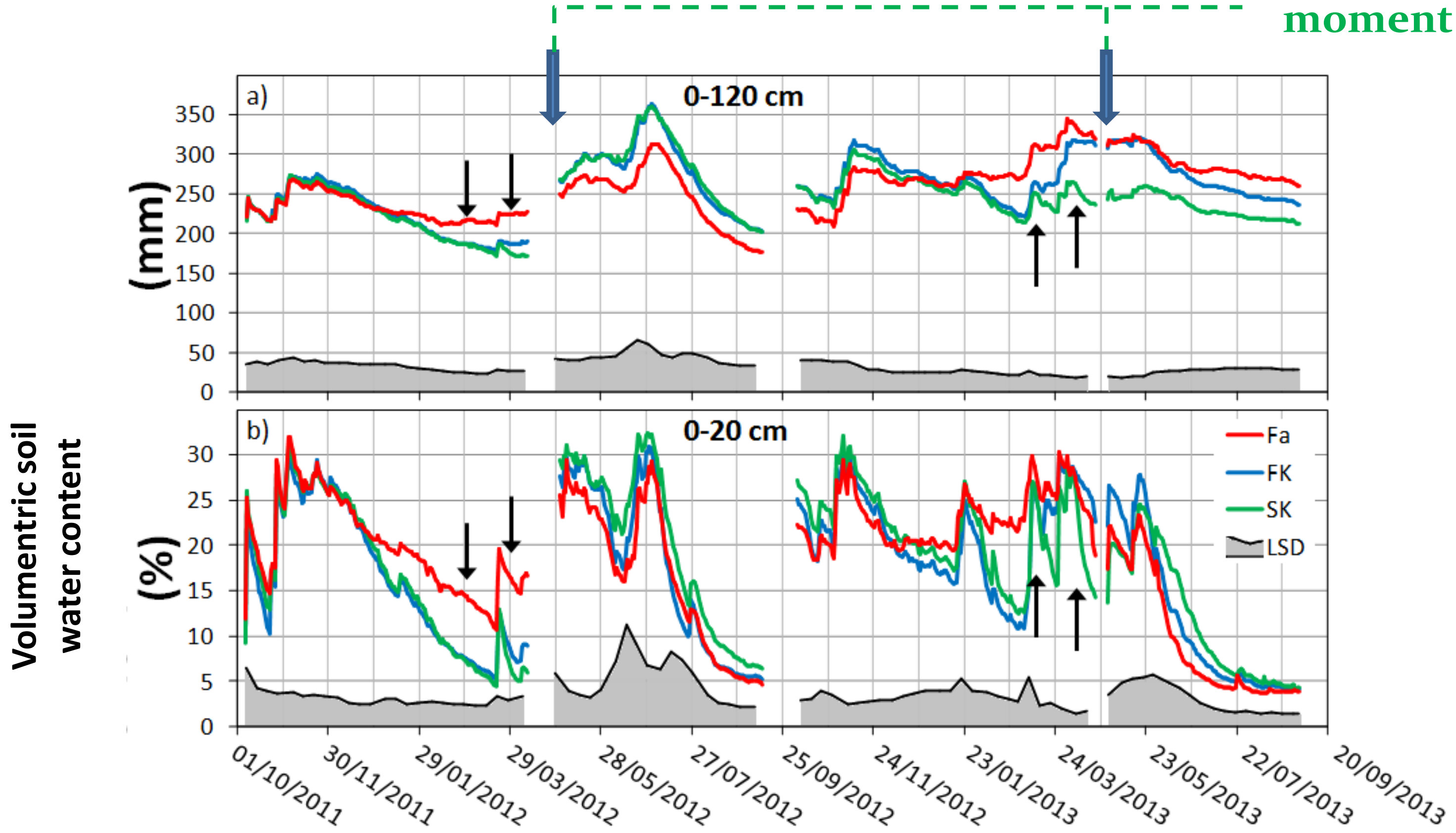
Cover crop treatments led to water risk competition??

(Alonso-Ayuso et al. 2014, Plos One)

RESULTS

Soil water content

Cash crop planting moment



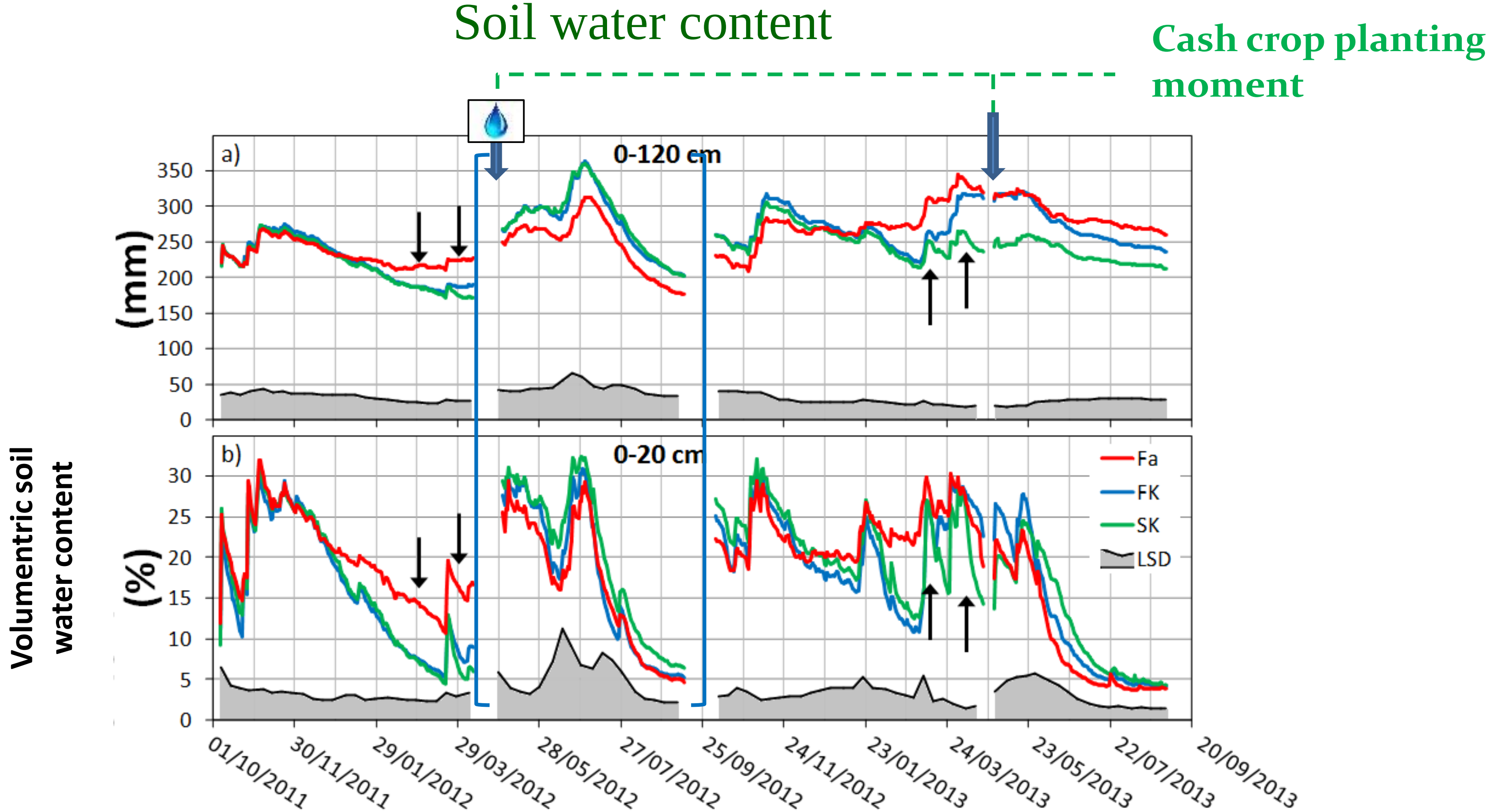
- Mulch → reduced soil water evaporation
- Dry years → water extraction by the cover crop killed later more dominant than water conservation effect

Water pre-emptive competition increase by SK treatment

(Alonso-Ayuso et al. 2014, Plos One)

RESULTS

Soil water content



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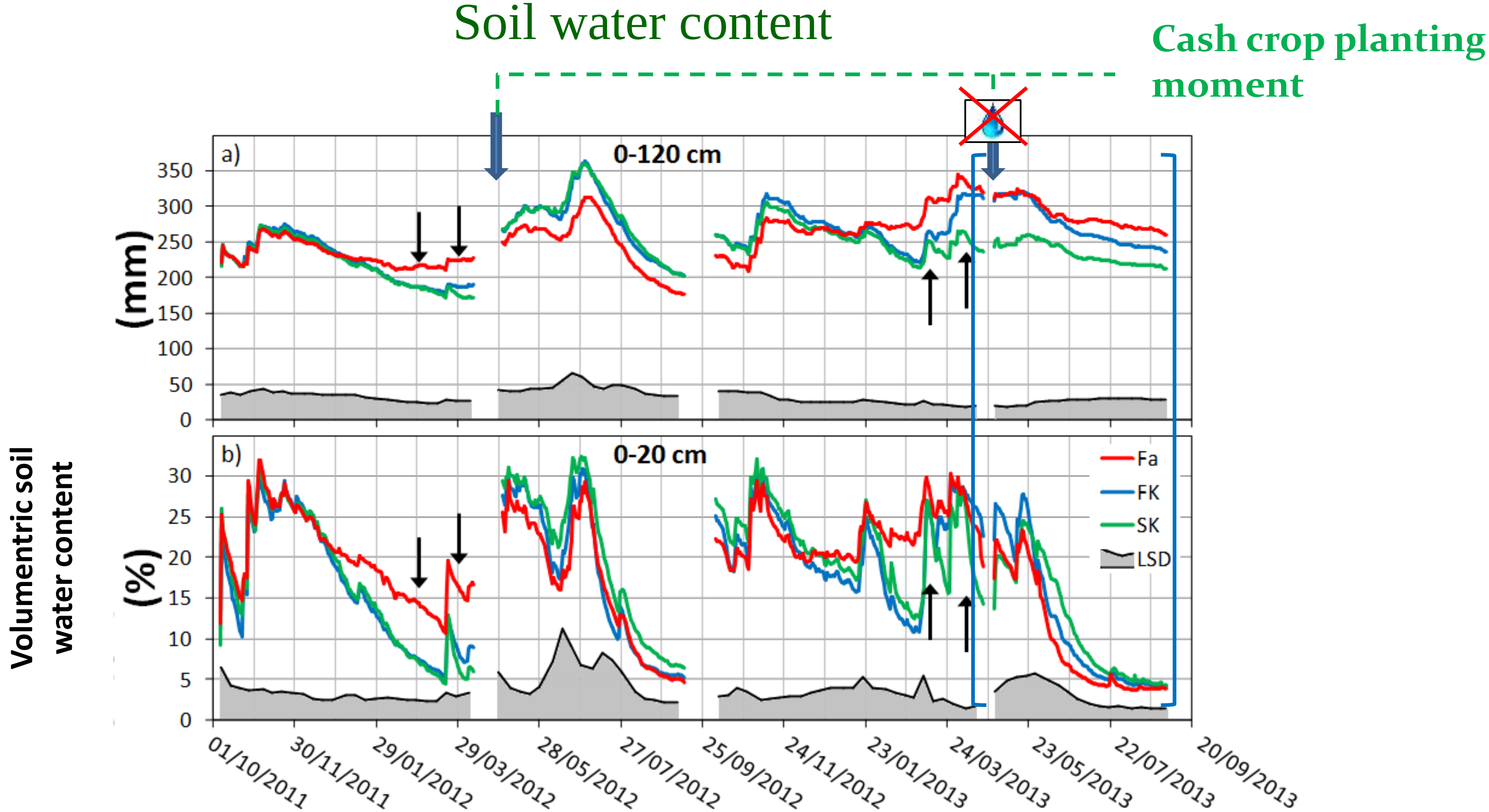

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CONCLUSIONS

- A delay in the cover crop killing allowed more growth that resulted in a bigger amount of residues in the soil and more resistant to decomposition.
- Cover crop showed an effect in scavenging available N from the soil profile and recycling it.
- Nitrogen leaching risk during autumn-winter was decreased, regardless of termination date.
- A delay in the cover crop kill date increased the N pre-emptive competition.
- In dry years, this delay can cause also a water pre-emptive competition with the cash crop: the water absorption by the living crop is bigger than the mulch effect of reducing evaporation.
- The mulch effect of water evaporation decrease was clear for the cover crop residues for an early kill date and for late kill date in rainy years or when irrigation exist.

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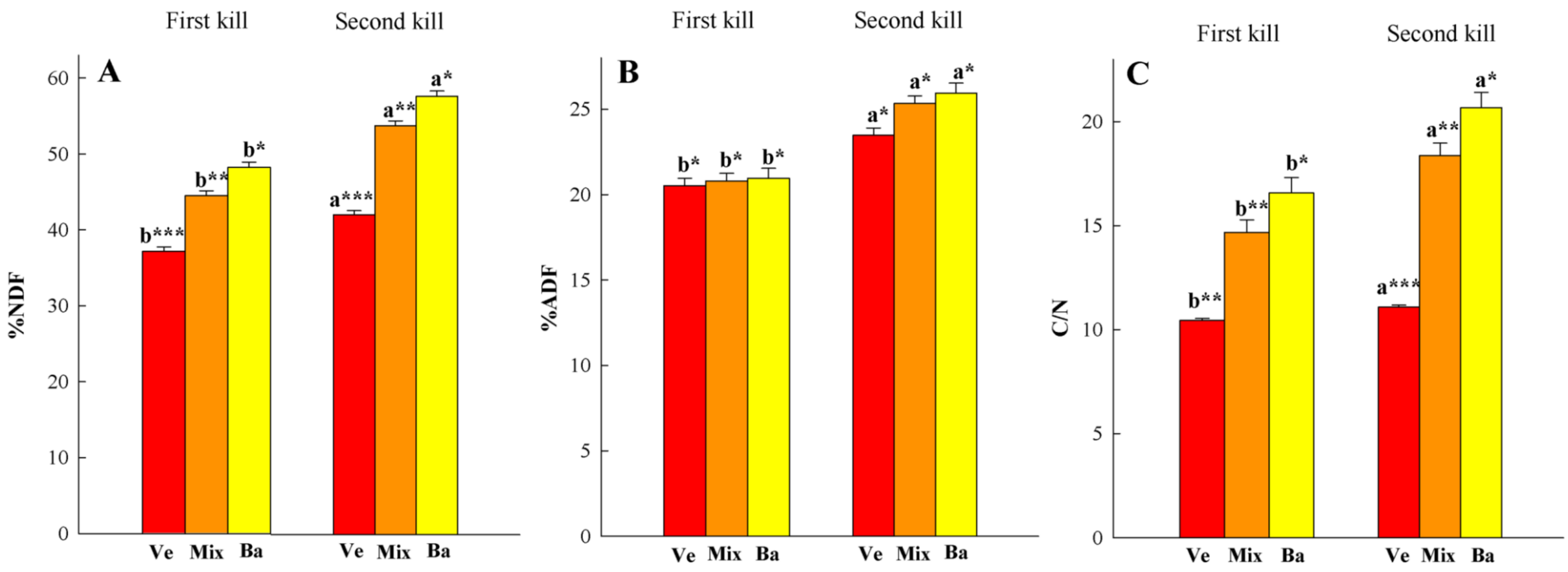
CONCLUSIONS

Killing date is a management tool crucial to maximize **cover crops benefits** in the ecosystem.

In semiarid regions, an **early kill date is recommended** in order to **reduce water and N competition** risk with the subsequent cash crop.

Thank you for your attention

Residue quality



- **CC kill date delay → more residues more resistent to decomposition**

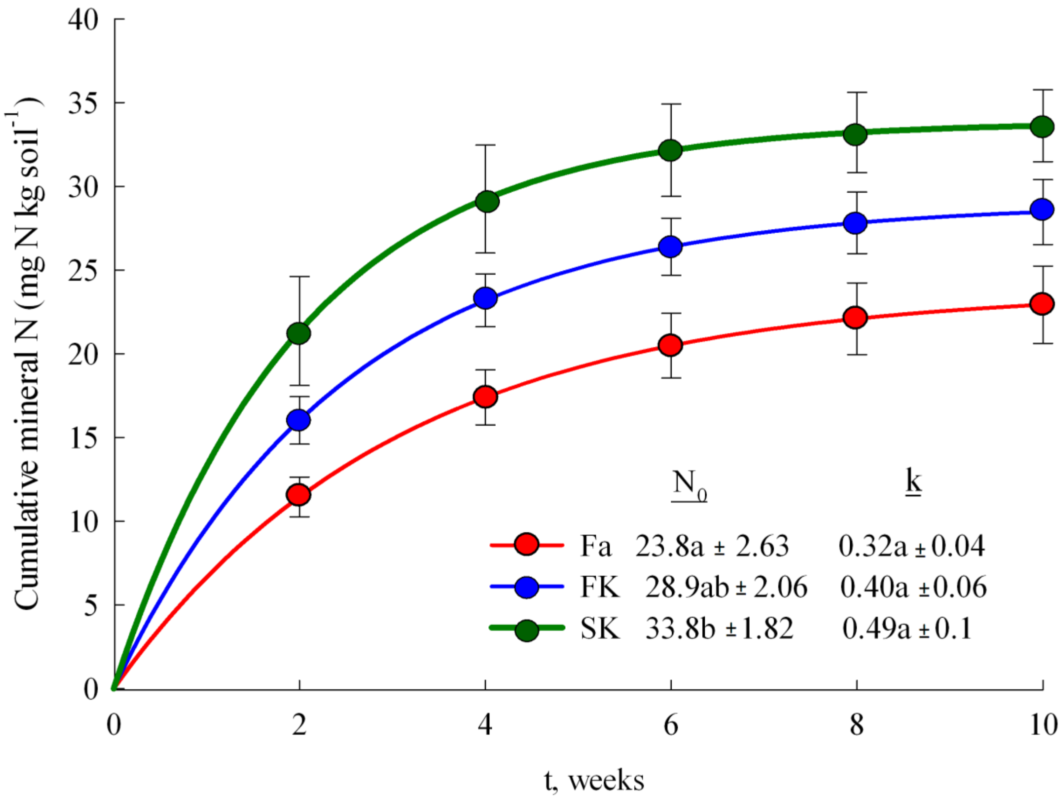
Residue quality

	% NDF		% ADF		% L		C/N	
	2011-2012							
	FK	SK	FK	SK	FK	SK	FK	SK
Barley	45.5 (0.58) b	56.35 (1.02) a	17.3 (0.45) b	22.02 (1.04) a	1.22 (0.17) b	2.91 (0.54) a	18.1 (1.23) b	21.2 (0.48) a
Vetch	37.4 (1.1) b	41.5 (0.74) a	17.1 (0.97) b	20.9 (0.73) a	4.83 (0.48)	5.91 (0.64)	11.1 (0.16) b	11.7 (0.17) a
Mixture	**43.4 (0.35) b**	**53.3 (1.62) a**	**17.3 (0.57) b**	**21.9 (0.8) a**	**2.19 (0.28) b**	**3.63 (0.22) a**	**16.2 (0.95) b**	**19.3 (0.78) a**
	2012-2013							
	FK	SK	FK	SK	FK	SK	FK	SK
Barley	50.9 (0.72) b	59.1 (1.85) a	24.6 (0.54) b	29.9 (1.45) a	1.69 (0.23)	2.17 (0.23)	15.1 (1.11) b	20.1 (1.72) a
Vetch	37.02 (0.39) b	42.8 (1.23) a	23.9 (0.53) b	26 (0.5) a	6.98 (0.31)	6.59 (0.37)	9.8 (0.09) b	10.5 (0.22) a
Mixture	**45.6 (0.59) b**	**54.4 (1.09) a**	**24.3 (0.51) b**	**28.8 (0.95) a**	**3.69 (0.21)**	**3.45 (0.05)**	**13.1 (0.76) b**	**17.4 (1.34) a**

- **CC kill date delay → more residues more resistent to decomposition**

RESULTS…

Potential N mineralization

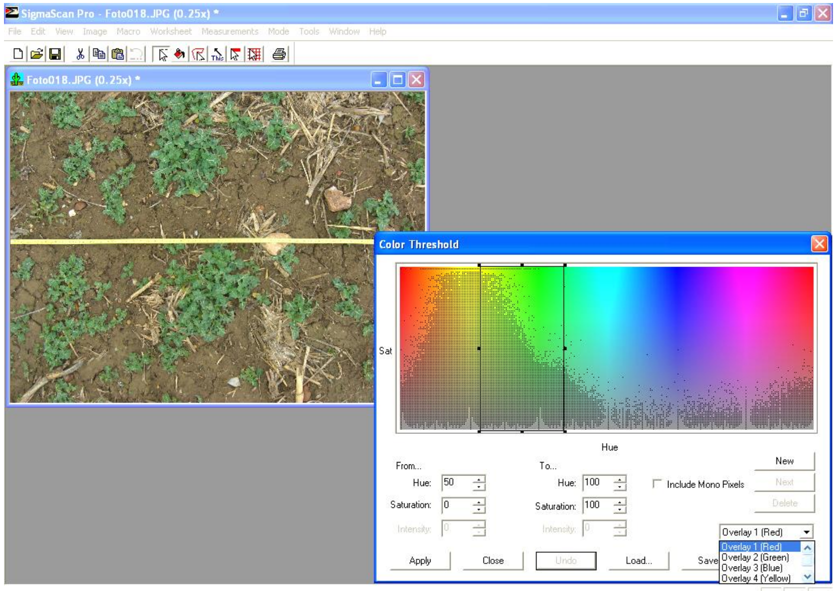


- N_o greater in CC treatment
- CC contribute to soil organic matter increase

Variables measured

- **Ground cover (GC)**
- Aerial biomass
- % C and N
- Residue quality
- N fixation
- Soil inorganic N content
- Soil N mineralization potential
- Soil water content

○ 2-week cover photos
○ Digital analysis → SigmaScan®Pro software
(Karcher and Richardson, 2001)



○ GC evolution adjusted to the Gompertz function
(Bodner et al., 2001)

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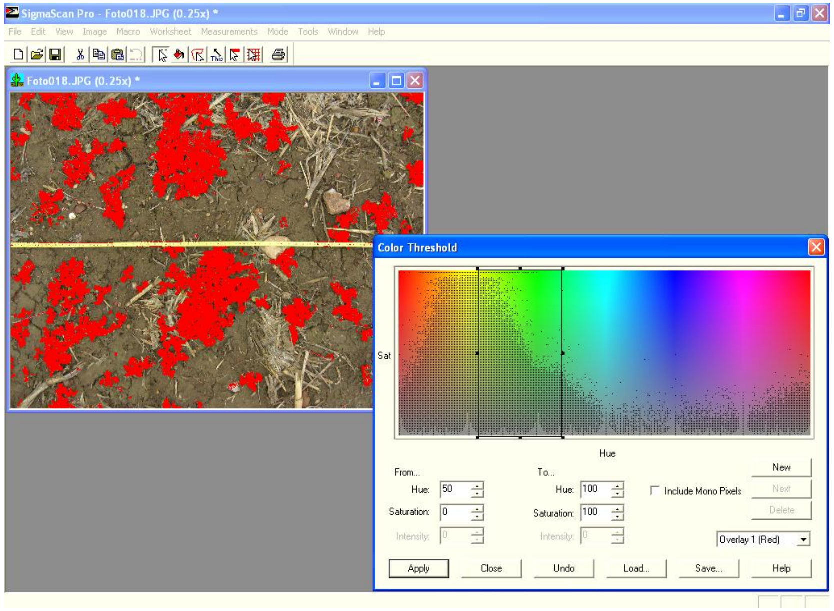

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○ Determined at the kill moment

○ **% C and N** (Dumas combustion method)

○ **Residue quality** (Goering & Van Soest, 1970)
- NDF: Nitrogen Detergent Fiber
- ADF: Acid Detergent Fiber
- L: Lignin

○ **N fixation**
- $\delta^{15}N$ (‰) determination (Europa Scientific 20-20 IRMS Analyser®, Crewe, UK)
- **Natural abundance method**
- Reference: barley as a sole crop in an adjacent field
(Unkovich et al., 2008)

Variables measured

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- % C and N
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- **Soil N mineralization potential**
- Soil inorganic N content
- Soil water content

- SK date, 2013
- Subsample (20 cm depth)
- Aerobic incubation (Standford & Smith, 1957)
- 10-week
- $N_t = N_0 \exp(-k\ t)$
  - $\mathbf{N_0}$ = soil N mineralization potential
  - **k** = mineralization rate constant

Variables measured

- Ground cover (GC)
- Aerial biomass
- % C and N
- Residue quality
- N fixation
- Soil inorganic N content
- Soil N mineralization potential
- **Soil water content (SWC)**

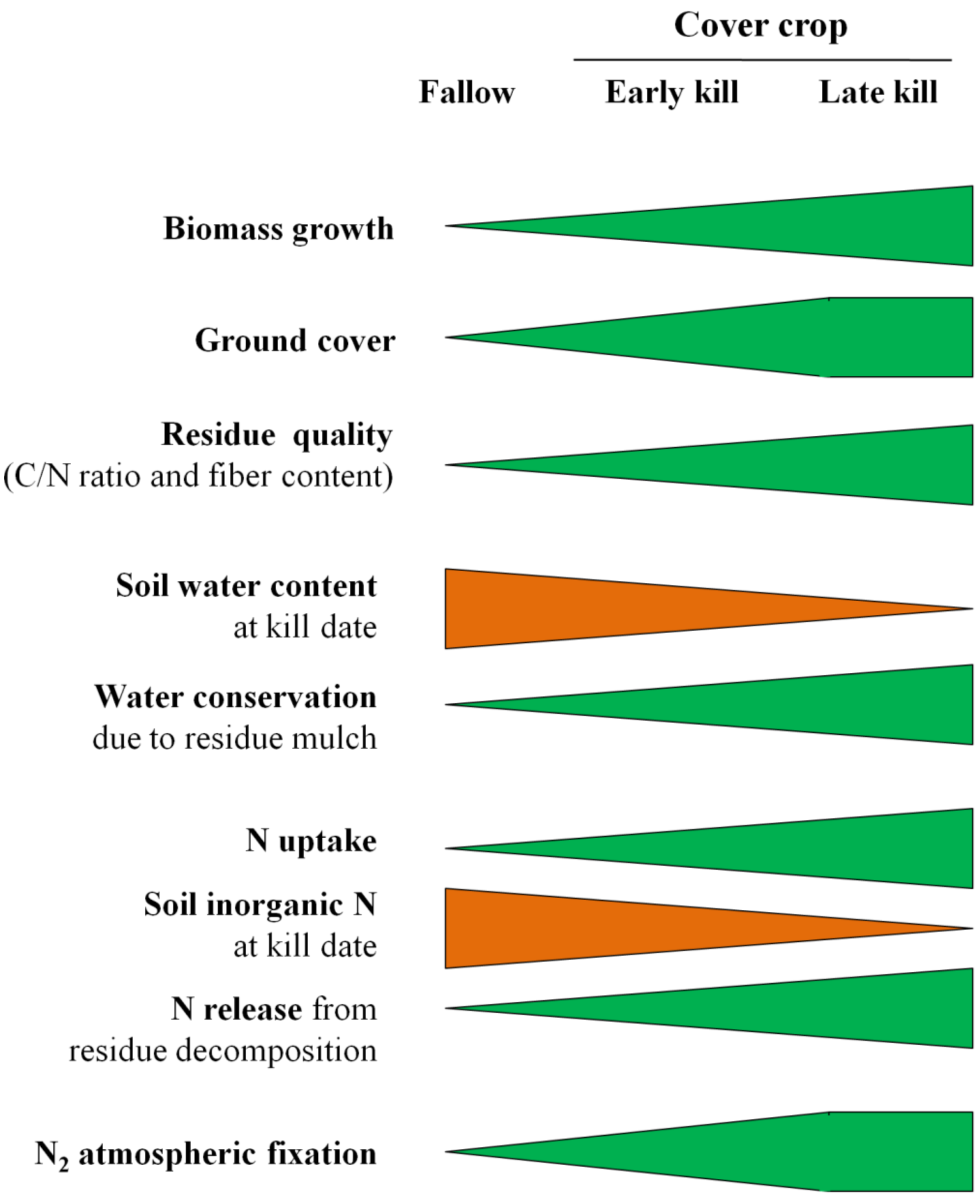
- Monitored daily
- EnviroScan® capacitance probes
- Sensors centered at:

  10, 30, 50, 70, 90, and 110 cm below the soil surface

Statistical analysis

- Analyses of variance (ANOVA) and t-test
- Means separated by Tukey's test ($P \leq 0.05$)
- LSD were calculated for SWC ($P\leq0.05$).
- Gompertz model was fitted to the GC and the N mineralization potential model was fitted to the cumulative N mineralized using a non-linear regression procedure
- PASW Statistics Software®

CONCLUSIONS



ECOSYSTEM SERVICES OF COVER CROPPING

- Soil erosion control
- Weed control
- More abundant and recalcitrant residues
- Enhance C sequestration
- Evaporation losses reduction

- Transpiration increase
- N immobilization risk increase
- Lower soil temperature → delay on cash crop sowing date in temperate climate

- Drainage and leaching control
- Improve sowing conditions in wet climate

- Pre-emptive water competition in dry climate

- N recycling (bottom/up) → fertilizer application reduction
- Nitrate leaching control

- Pre-emptive soil N competition → fertilizer application increase

- N available increase
- Enhancement of N and C coupling

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