



Increasing the share of forage leguminous crops in the crop rotation positively affects the soil organic carbon stocks – Analysis of European LTEs

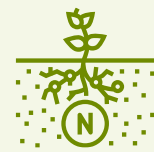




# WHY LEGUMES?



Significant role in human and animal nutrition they are a major source of plant protein



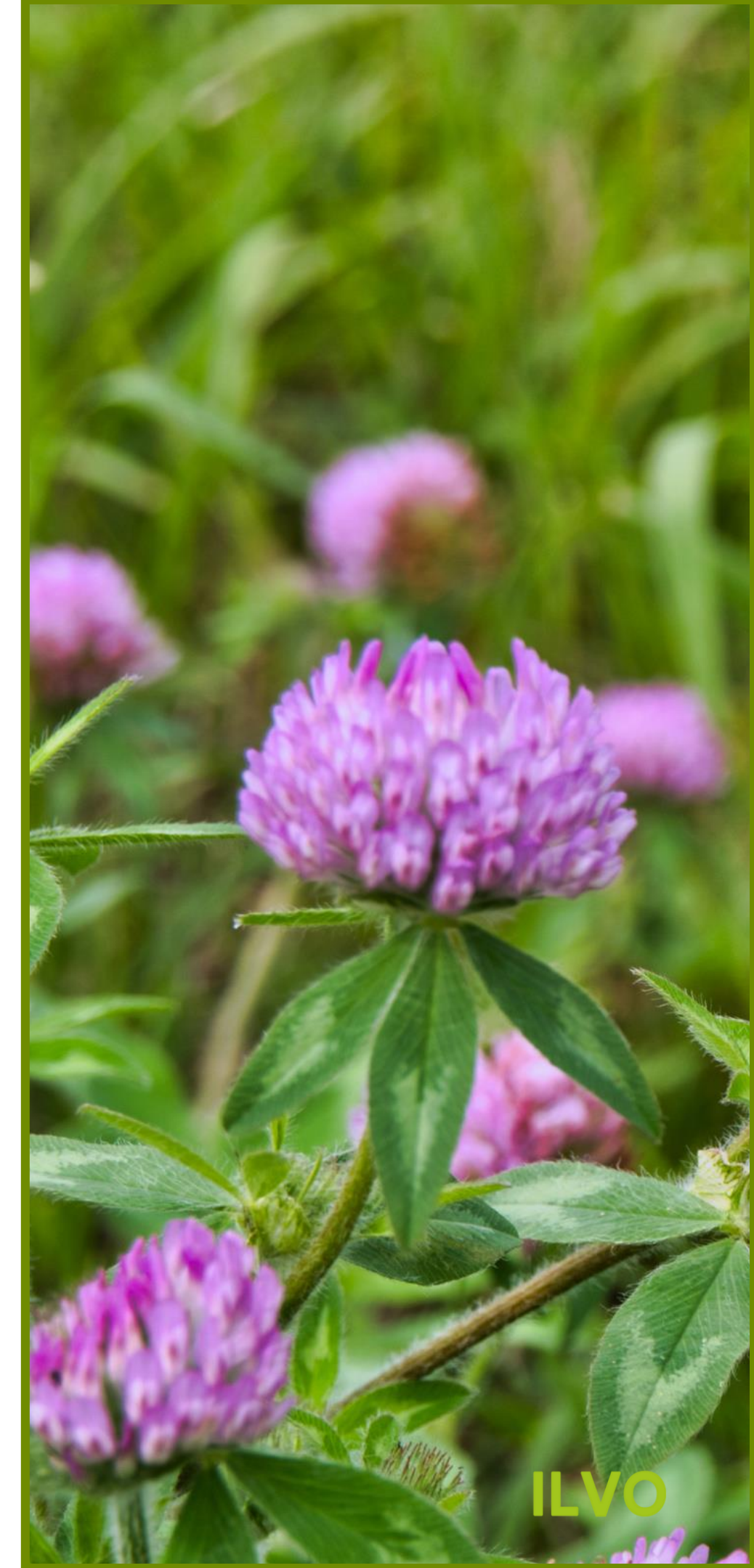
Increased environmental sustainability due to their ability to fix atmospheric nitrogen



Often higher yields and better-quality produce for the subsequent crops

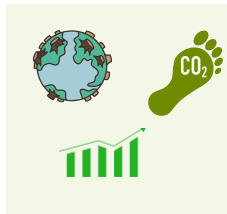


Can contribute to crop diversification and sustainable farm intensification as provide numerous agronomic and environmental benefits





# LEGUMES IN EUROPE



The EU is highly dependant on protein crops imports related to environmental burdens in the areas of origin such as deforestation and GHG emissions - only 3% of the arable land



The EU-protein self-sufficiency is a long-standing topic on the EU political agenda the last decades

## -> **EU protein strategy (2023)**

- Fostering EU-grown plant proteins
- Reduce the demand for import dependency
- Measures to avoid & minimize EU contribution to global afforestation and degradation



Legume-based crop rotations are included in the list of practices that can be supported by the Eco-schemes under the CAP 2023-2027 and the EU Green Deal





# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## METHODOLOGY

### To estimate change in SOC stocks:

A **reference scenario** against which other practices are being compared

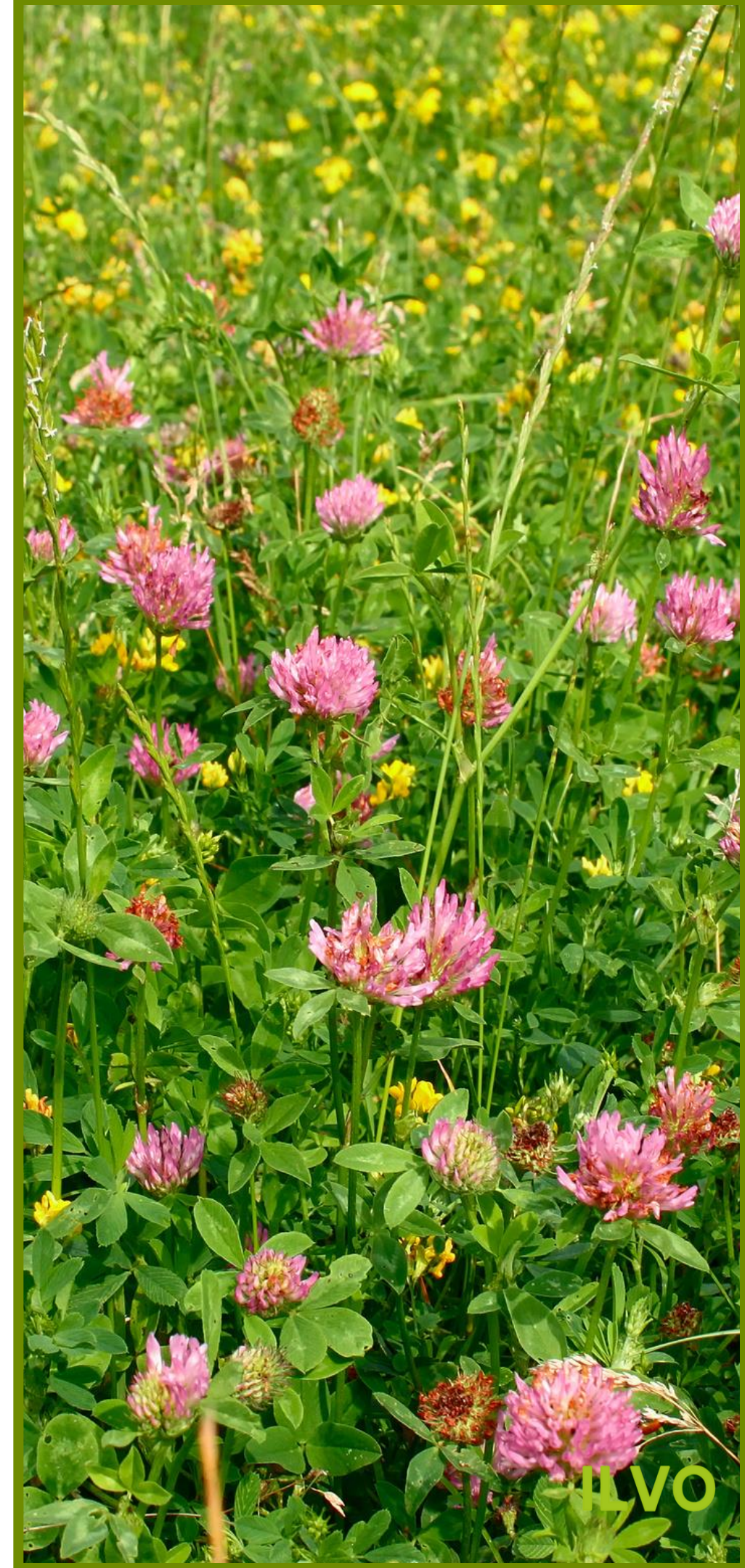
Difficulty for rotation: each rotation is different

Solution: calculate the share of each crop presence in the rotation

The change in SOC stocks resulting from including higher share of legumes in the rotation is then calculated and expressed as a ratio of the SOC stocks in the reference scenario.

$$EF_{relative} = \frac{SOC_{stocks\ treatment}}{SOC_{stocks\ control}}$$

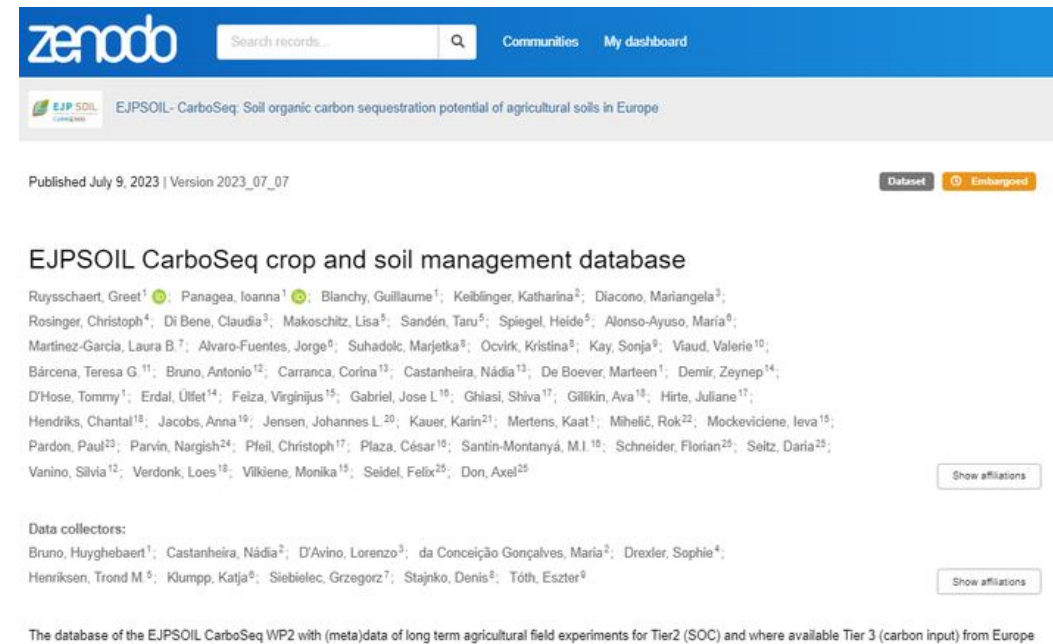
latest data points available for maximum 30 cm depth





# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## METHODOLOGY



zenodo Search records... Communities My dashboard

EJP SOIL EJP SOIL CarboSeq: Soil organic carbon sequestration potential of agricultural soils in Europe

Published July 9, 2023 | Version 2023\_07\_07 Dataset Embargoed

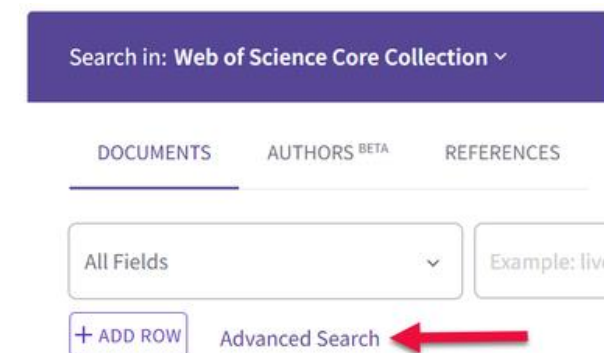
**EJP SOIL CarboSeq crop and soil management database**

Ruysschaert, Greet<sup>1</sup>; Panagea, Ioanna<sup>1</sup>; Blanchy, Guillaume<sup>1</sup>; Keibinger, Katharina<sup>2</sup>; Diacono, Mariangela<sup>3</sup>; Rosinger, Christoph<sup>4</sup>; Di Bene, Claudia<sup>5</sup>; Makoschitz, Lisa<sup>6</sup>; Sandén, Taru<sup>7</sup>; Spiegel, Heide<sup>8</sup>; Alonso-Ayuso, María<sup>9</sup>; Martínez-García, Laura B.<sup>7</sup>; Alvaro-Fuentes, Jorge<sup>9</sup>; Suhadolc, Marjetka<sup>5</sup>; Ocvirk, Kristina<sup>5</sup>; Kay, Sonja<sup>9</sup>; Vlaud, Valerie<sup>10</sup>; Bárcena, Teresa G.<sup>11</sup>; Bruno, Antonio<sup>12</sup>; Carranca, Corina<sup>12</sup>; Castanheira, Nádia<sup>13</sup>; De Boever, Marteen<sup>1</sup>; Demir, Zeynep<sup>14</sup>; D'Hose, Tommy<sup>1</sup>; Erdal, Ulfit<sup>14</sup>; Felza, Virginijus<sup>15</sup>; Gabriel, Jose L.<sup>16</sup>; Ghiasi, Shiva<sup>17</sup>; Gillkin, Ava<sup>18</sup>; Hirte, Juliana<sup>17</sup>; Hendriks, Chantal<sup>18</sup>; Jacobs, Anna<sup>10</sup>; Jensen, Johannes L.<sup>20</sup>; Kauer, Karin<sup>21</sup>; Mertens, Kaat<sup>1</sup>; Mihelič, Rok<sup>22</sup>; Mockeviciene, Ieva<sup>19</sup>; Pardon, Paul<sup>23</sup>; Parvin, Nargish<sup>24</sup>; Pfeil, Christoph<sup>17</sup>; Plaza, César<sup>15</sup>; Santin-Montanyà, M.I.<sup>15</sup>; Schneider, Florian<sup>25</sup>; Seltz, Daria<sup>25</sup>; Vanino, Sílvia<sup>12</sup>; Verdonk, Loes<sup>18</sup>; Vilkiene, Monika<sup>15</sup>; Seidel, Felix<sup>25</sup>; Don, Axel<sup>25</sup>

Data collectors:  
Bruno, Huyghebaert<sup>1</sup>; Castanheira, Nádia<sup>2</sup>; D'Ávino, Lorenzo<sup>3</sup>; da Conceição Gonçalves, Maria<sup>2</sup>; Drexler, Sophie<sup>4</sup>; Henriksen, Trond M.<sup>5</sup>; Klumpp, Katja<sup>6</sup>; Siebielec, Grzegorz<sup>7</sup>; Stajko, Denis<sup>8</sup>; Tóth, Eszter<sup>9</sup>

The database of the EJP SOIL CarboSeq WP2 with (meta)data of long term agricultural field experiments for Tier2 (SOC) and where available Tier 3 (carbon input) from Europe

Clarivate  
**Web of Science™**



Search in: Web of Science Core Collection ▾

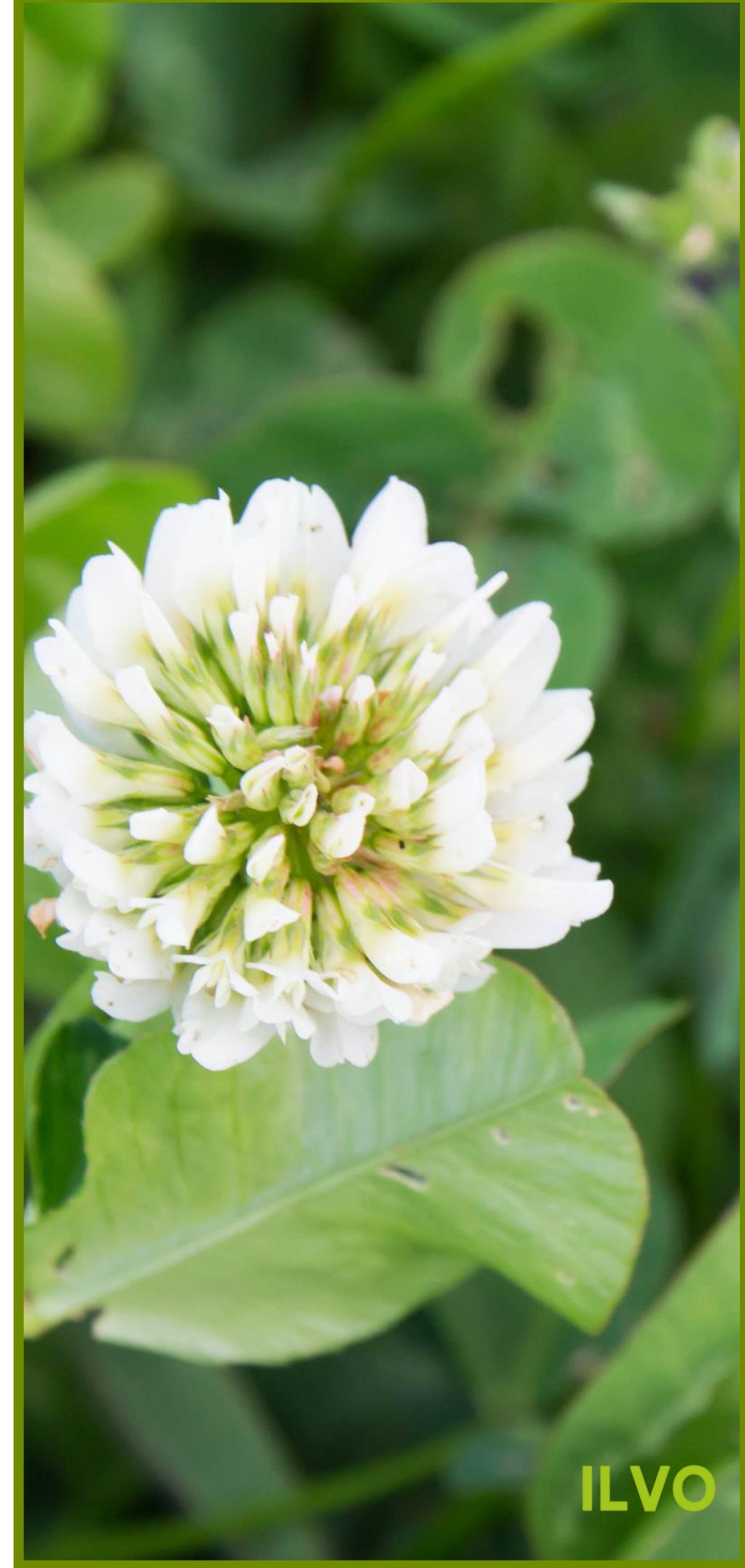
DOCUMENTS AUTHORS BETA REFERENCES

All Fields ▾ Example: live

+ ADD ROW Advanced Search

**Structured query for additional published literature**

Increased share of legumes in the rotation:  
  
32 experiments  
72 pairs of control and management treatment.



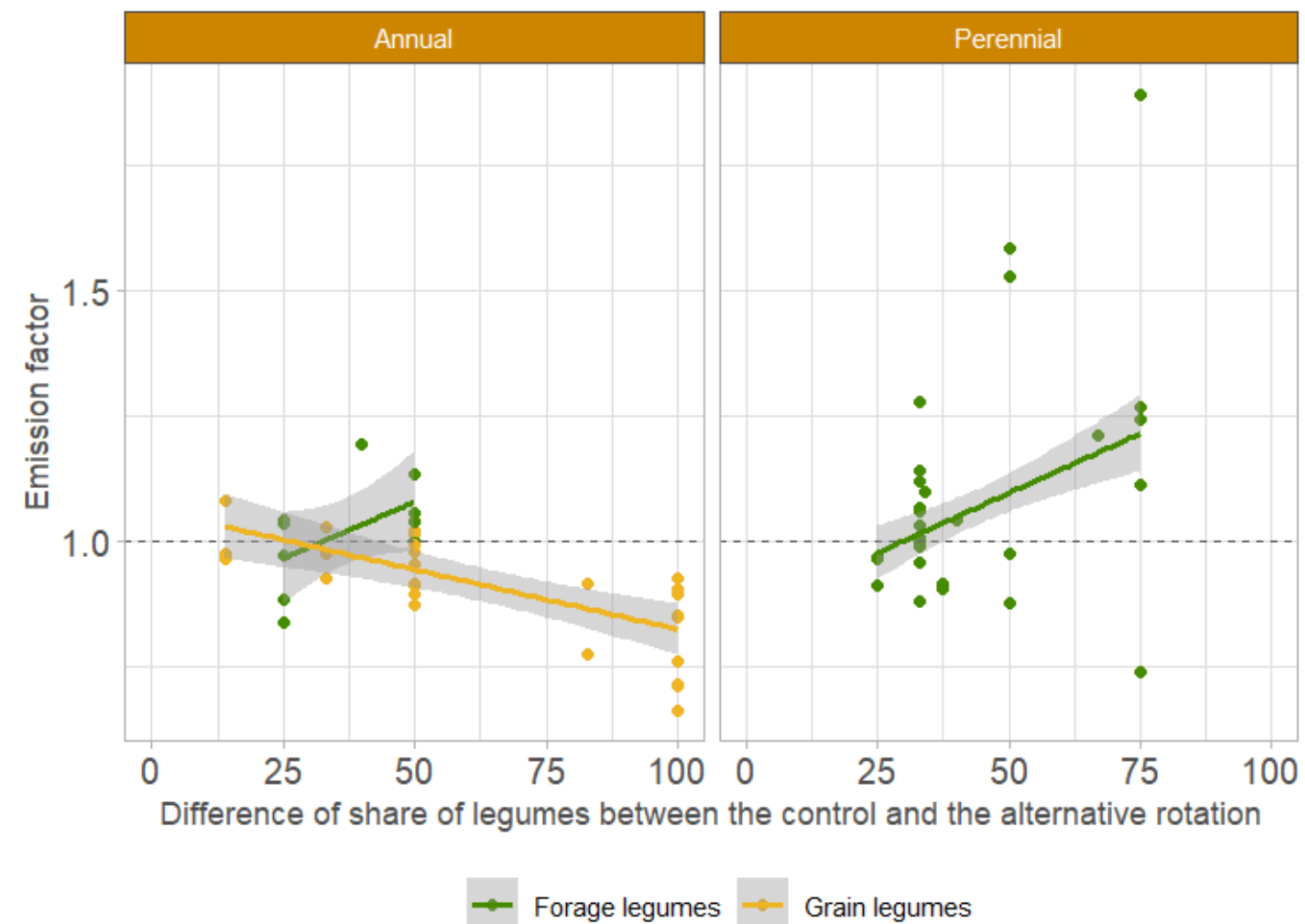


# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## RESULTS

Exploration of the dataset:

- Type of legumes: forage legumes (alfalfa, clover..) vs grain legumes (chickpeas, soy...)
- Duration of the growing period: annual vs perennial and specific duration
- Alternative management type: expansion of the rotation, temporary ley, cereal monoculture replacement, intercropping...



Statistically significant  
difference between forage  
and grain legumes





# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## RESULTS

## FOCUS ONLY ON FORAGE LEGUMES



The final dataset used for further analysis included 21 experiments located in 9 different countries with 39 pairs of treatments and control



### Legumes in the treatments

Alfalfa (*Medicago sativa*)



n=15

Vetches (*Vicia*)

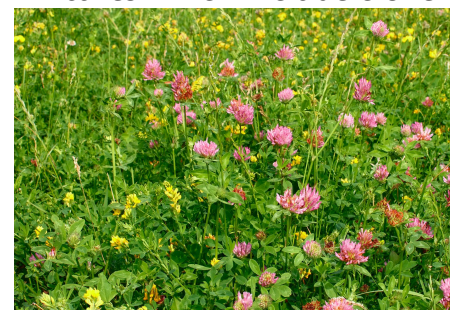


n=7

Clovers (*Trifolium*)

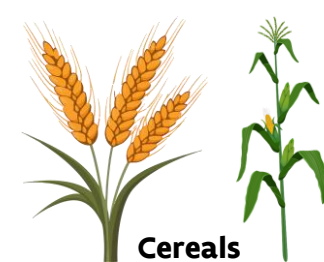


Mixtures which include clovers

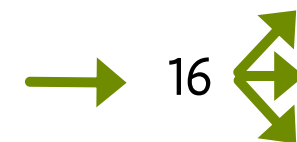


n=15

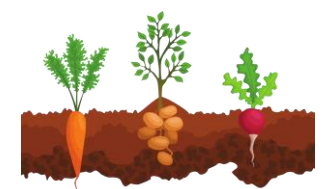
### Crop types replaced by legumes



Cereals



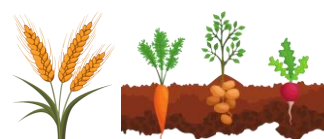
- 2 Alfalfa
- 7 Vetch
- 7 Clover / mixtures



Root crops



- 2 Alfalfa
- 2 Clover / mixtures



Cereals & Root crops



- 5 Alfalfa



# WHAT IS THE EFFECT OF LEGUMES ON SOC?

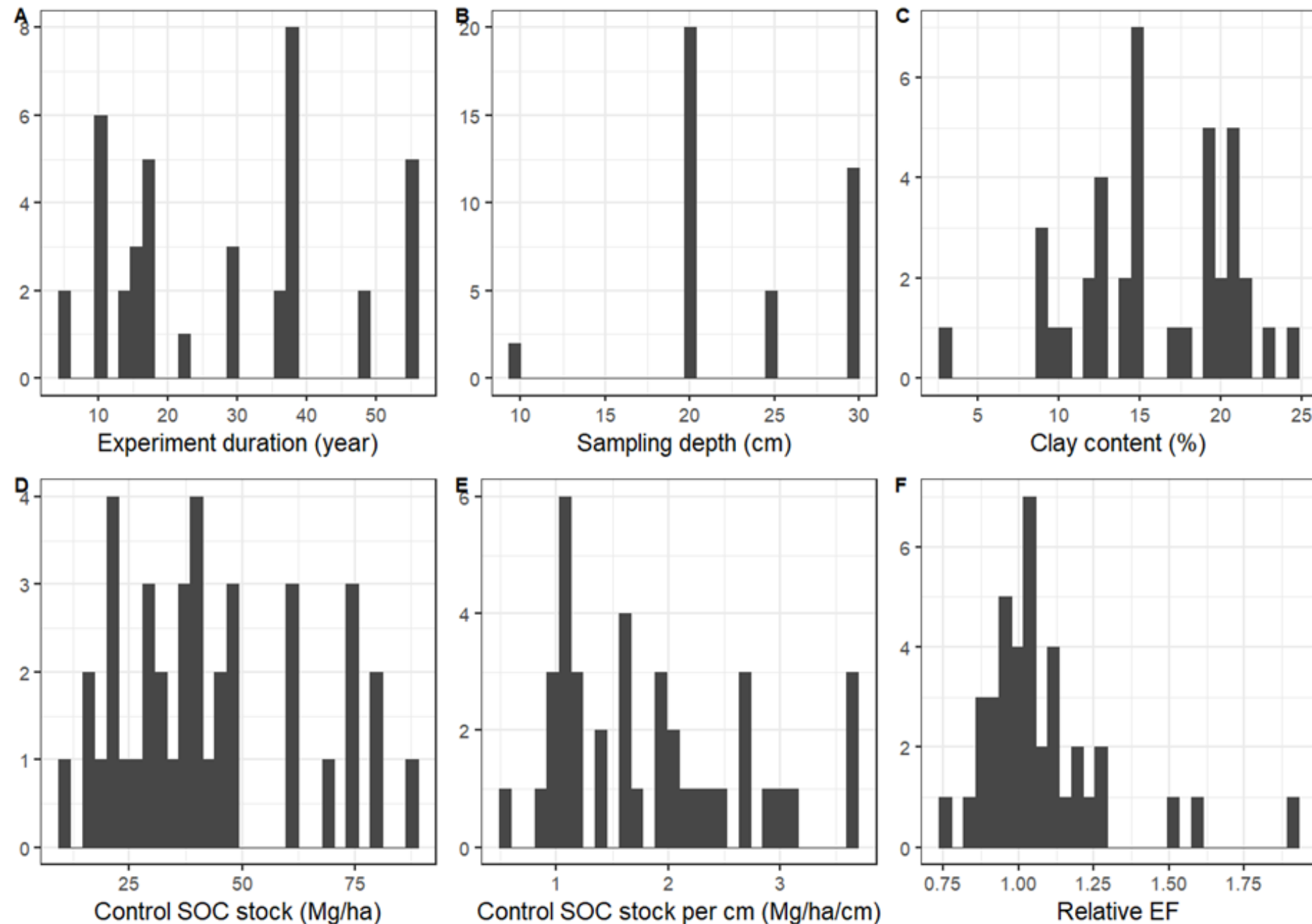
## RESULTS

**Identify important predictors affecting the EFs**

Climate: Temperature, rainfall, climatic zone, aridity index.. .

Management: crop type, replacement crop, crop growth duration

Soil properties: textural class, clay content, baseline SOC



**Linear mixed models,  
backwards  
elimination**

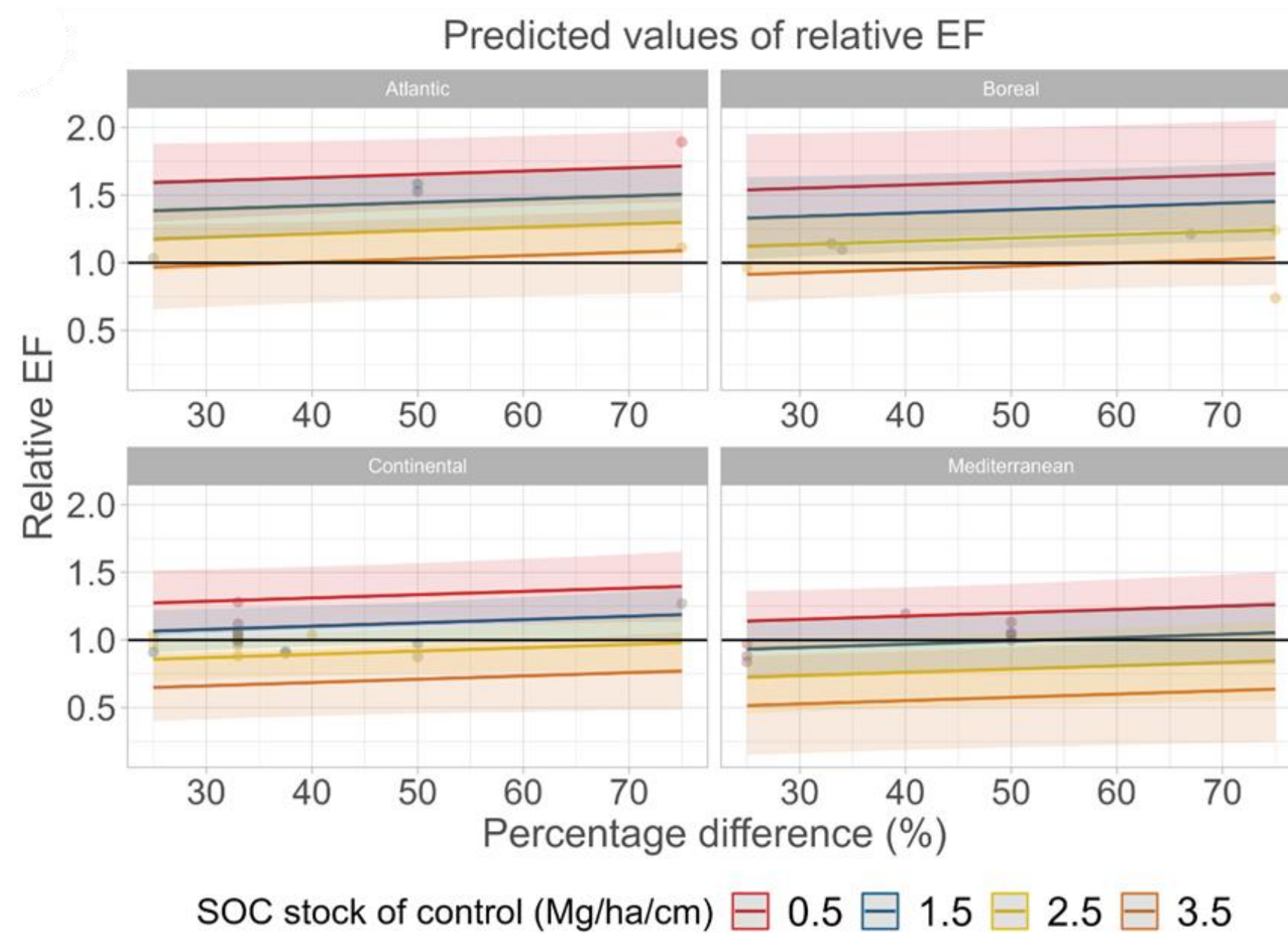
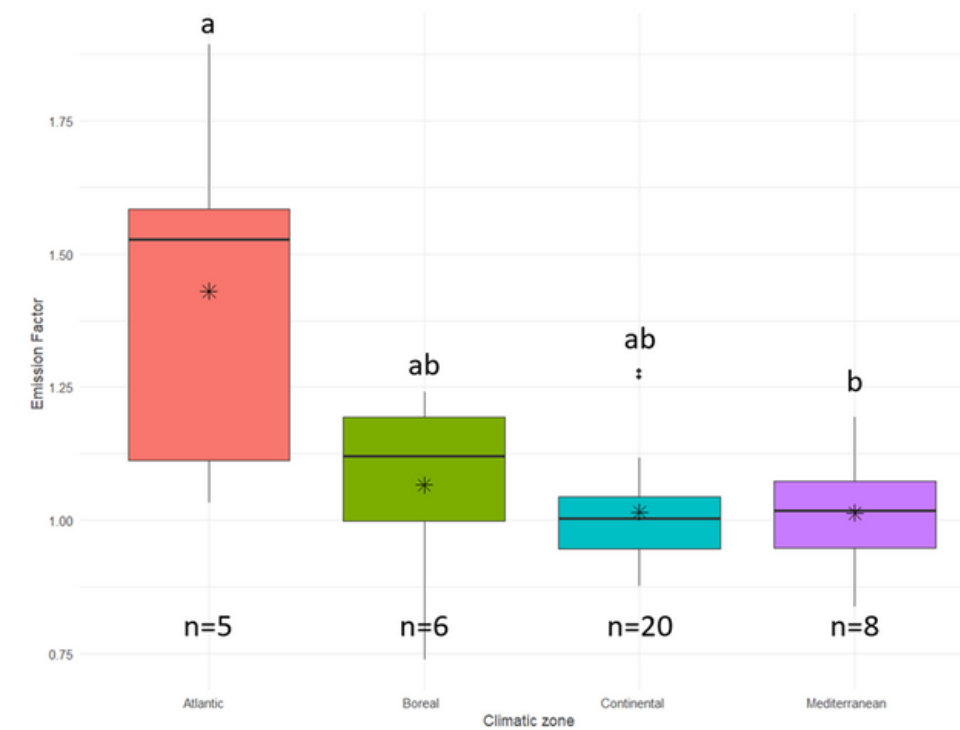




# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## RESULTS

**EF ~ LEGUMES PERCENTAGE DIFFERENCE + SOC STOCK OF THE CONTROL PER CM + CLIMATIC ZONE**



The distribution of available data is not balanced among and within the different climatic zones apart from the Continental climatic zone.

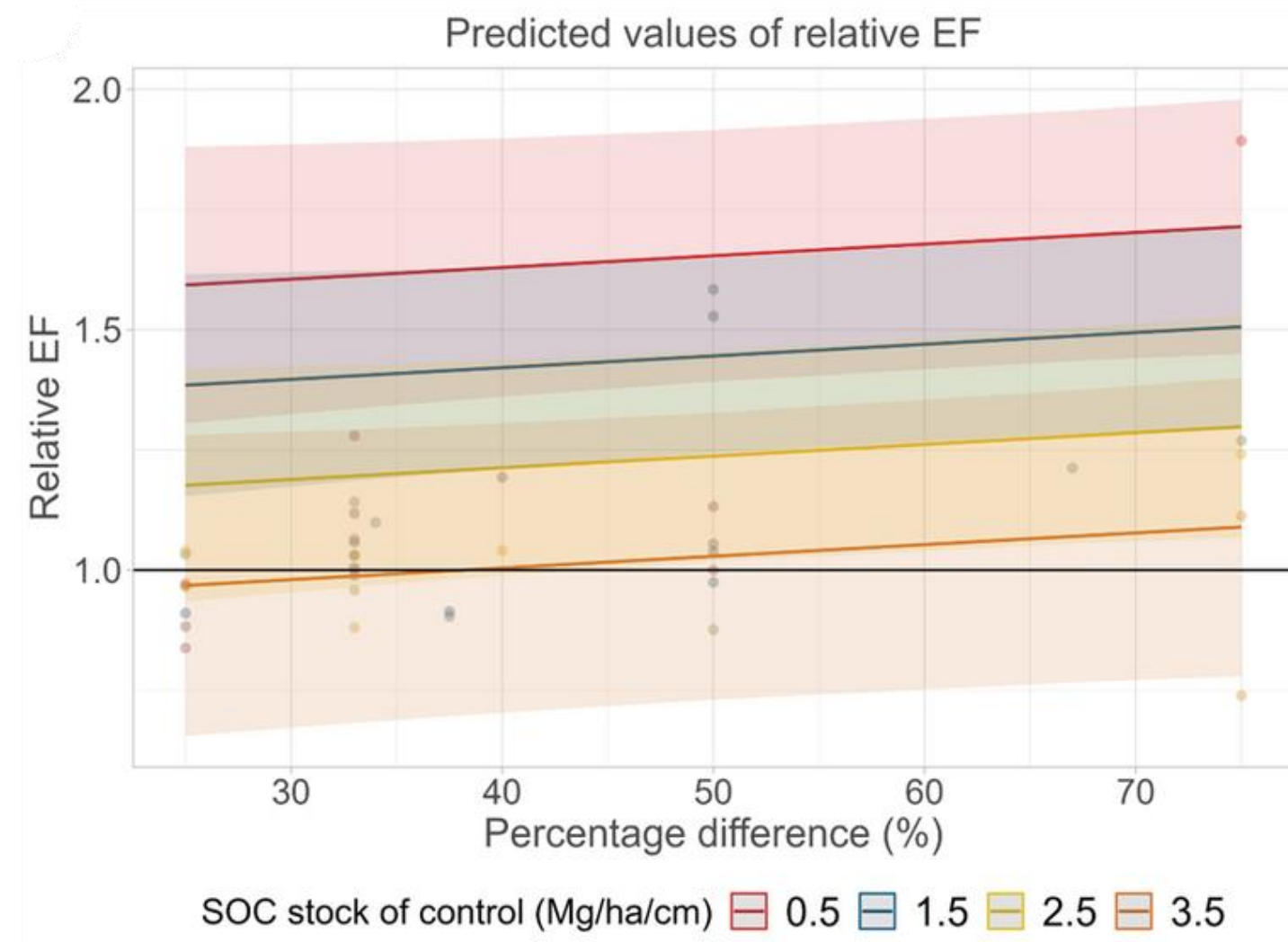




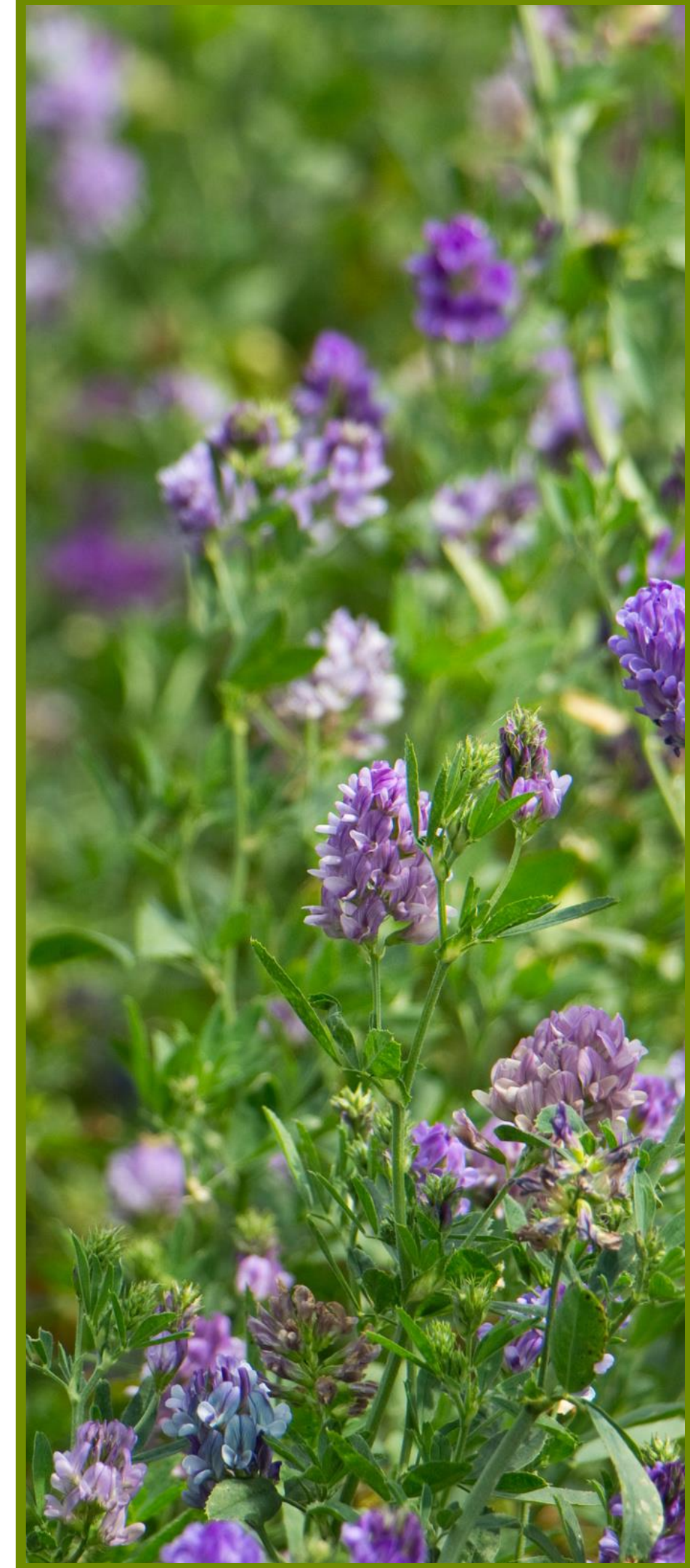
# WHAT IS THE EFFECT OF LEGUMES ON SOC?

## RESULTS

**EF ~ legumes percentage difference + SOC stock of the control per cm**



$$EF = 1.182198 + 0.003957 * \text{percentage difference} - 0.129105 * \text{SOC of the control per cm}$$





# LEGUMES



The type of legume species included in a crop rotation affects the SOC accrual



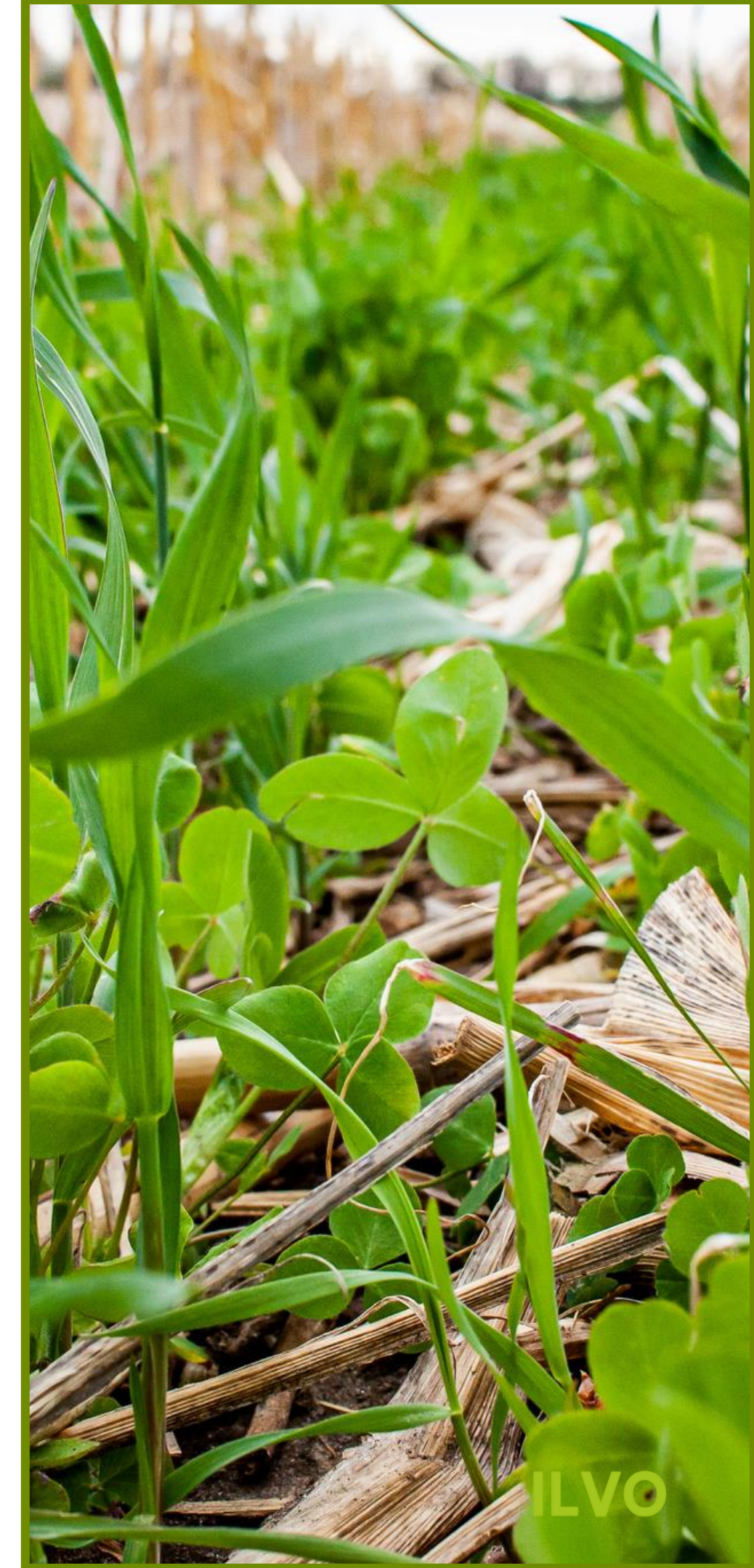
Increasing the share of forage legumes in crop rotations can lead to SOC accrual in the European croplands



The regression equation proposed, can be used for estimating SOC changes caused by the inclusion of more forage legumes in the rotations – considering the limitations



Forage legumes can increase the sustainability of a cropping system and contribute to the European protein strategy





# Questions or suggestions?

Contact us

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