Theme 1
Status and trends of global soil nutrient budget

The potential of cereal-legume intercropping in lowering the agriculture's carbon footprint

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INTRODUCTION

The incorporation of agroecological practices in agriculture that tend to sequester C in the soil contribute to climate change mitigation.

The capacity and duration of atmospheric C storage in crop biomass and ultimately in soil as organic C is known for many sole crops. However, little is known about the long-term stability of C transferred to soils and its dynamics in soils grown with intercrops.

Two hypotheses were tested: 1- long-term intercropping of barley -C- (*Hordeum hexastichon* L) with field bean -Fb- (*Vicia faba* minor Beck) affects the C mineralization potential of the soil and consequently its microbial activity, and 2- this effect is intensified by inorganic N and P fertilization.

METHODS

The experiment (2017/18, 2018/19, 2019-20) was carried out at the 'Rottaia' experimental station of the University of Pisa, Italy.

EXPERIMENTAL DESIGN

The layout was a split-plot design. Fertiliser treatment was the main plot: 0 and NP (120 kg N ha^{-1} and 100 kg P ha^{-1}) and the cropping systems the subplot.

The 1:1 IC was arranged by alternating one row of C with one row of Fb. Both IC and sole crops (SC) were sown at 100 seeds m^{-2}.

FIELD LAYOUT

The plots of the cropping systems were arranged in strips perpendicular to fertiliser treatments:

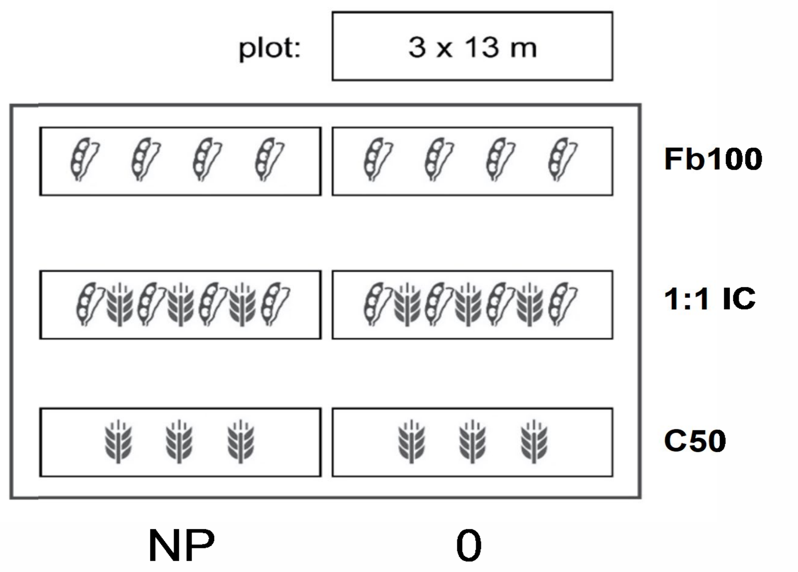

Figure 1. Arrangement of experimental plots in both fields during the three growing seasons.

SC were rotated (fig. 2) and IC, conversely, were sown, on a bare soil. The IC sown on new bare soil was named as New, while the IC cultivated after themselves as Old: two and three years old.

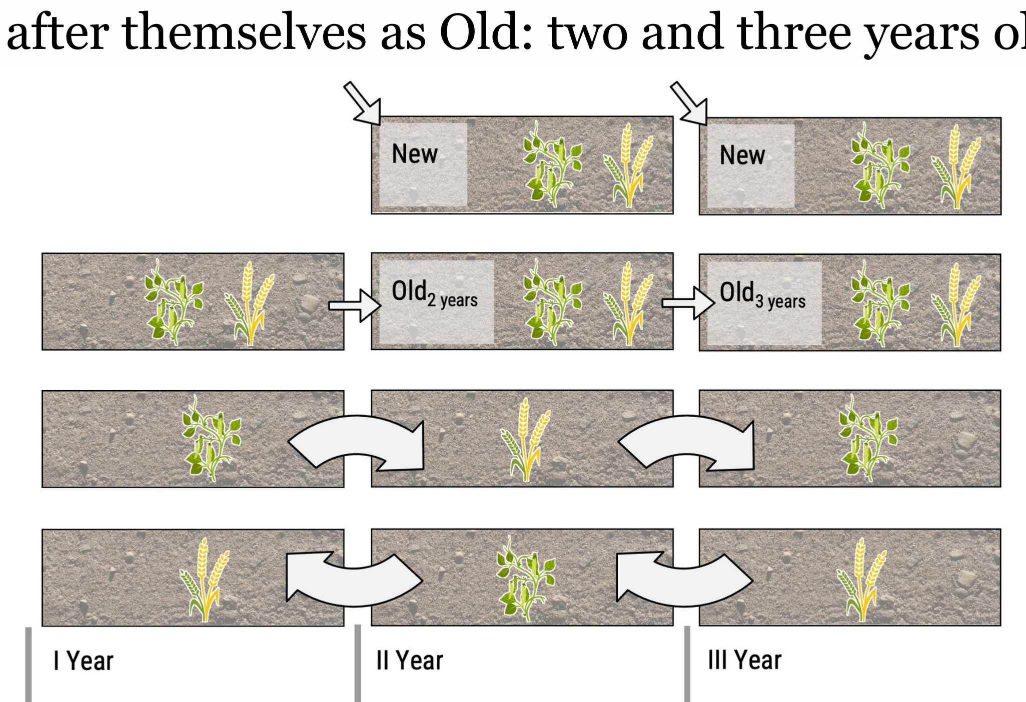

Figure 2. Graphical representation of the New and Old intercrop treatments and crop rotation in the sole crops.

SOIL SAMPLING

Six cores of 750 cm³ were randomly dug from the 0-20 cm soil profile and bulked to obtain a replicate of 4500 cm³. Soil samples were air-dried and sieved before analysis.

SOIL ANALYSIS

Soil respiration (SR) was determined by Isermeyer method (1952) that estimates the CO_2 evolved during the incubation of soil in a closed system. The soil samples were rehydrated and kept at 60% of water holding capacity and incubated at 25 °C (optimum environmental conditions for biological activity).

The cumulated C mineralization (Cmin) was calculated after each period of incubation. Basal respiration is referred as the respiration without the addition of organic substrate to soil.

RESULTS

NP levels did not affect the measured parameters.

The soil samples of the cropping systems differed significantly in SR and Cmin, but only at the first 48 hs of incubation.

The SR of C50 was the highest and was 21.5% higher than Fb100. The SR of New 1:1 IC was by 20.2% higher than that of Old 1:1 IC. The same ranking, C50 > New 1:1 IC ≥ Fb100 ≥ Old 1:1 IC was observed for the Cmin.

Table 1. Rates of CO_2 release and C mineralization at 48 hours of soil incubation, as affected by cropping system. *Different letters reveal significant differences at 0.05 probability level, Tuckey test.

Cropping system	CO_2 release (mmol day^{-1} kg^{-1})	C mineralization (mg C 100 g^{-1} day^{-1})
C50	2.26 a	2.71 a
Fb100	1.77 bc	2.12 bc
New 1:1 IC	1.98 b	2.38 b
Old 1:1 IC	1.58 c	1.90 c

SR declined sharply after 48 hs of incubation and remained nearly constant, from day 5 to day 20. This indicates the rapid depletion of immediately available C and highlight that conditions of basal respiration were attained from five days of incubation on.

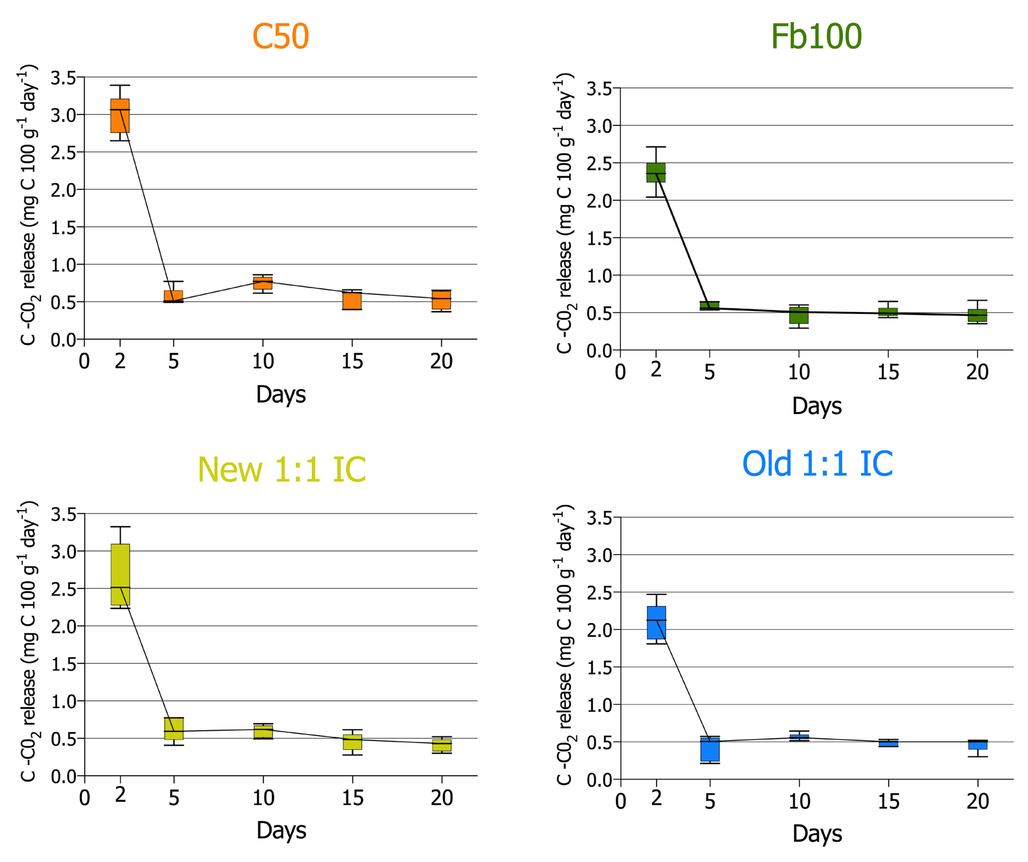

Figure 3. Soil respiration rates as affected by cropping system and time of incubation (n=6)

The amount of Cmin increased progressively with incubation time in all cropping systems, (demonstrated by linear equations). The slope of Cmin was 18.2% higher in the C50 soil than the Fb100, New 1:1 IC and Old 1:1 IC.

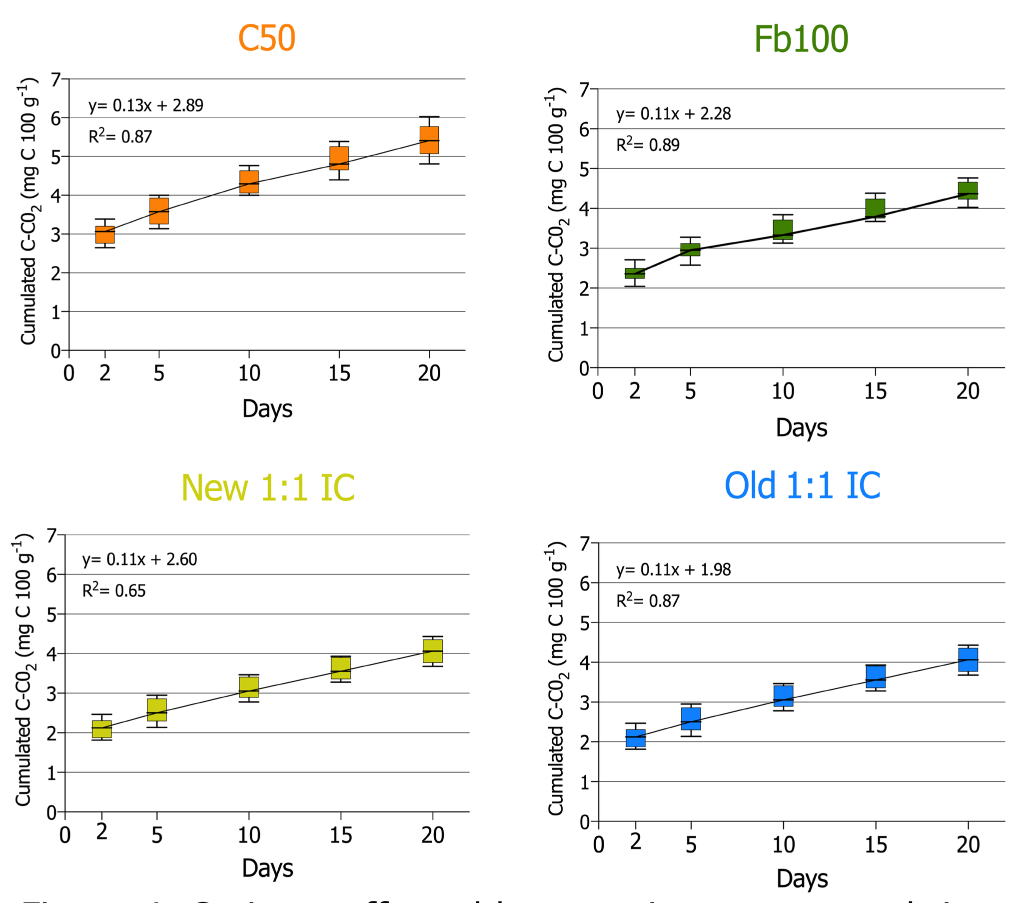

Figure 4. Cmin as affected by cropping system and time of incubation. (n=6).

The amount of Cmin of C50 over the entire period of incubation was 18.4% higher than Fb100, and 12.6 and 24.7% higher than New 1:1 IC and Old 1:1 IC, respectively. This may be due to IC decreases the soil C/N ratio compared to SC, regardless of their composition and the presence of legumes that increase the atmospheric N.

Table 2. Cumulated Cmin during 20 days of soil incubation. *Different letters within a column reveal significant differences at 0.05 probability level, Tuckey test.

Cropping system	*Cumulated C_{min} (mg C 100 g^{-1})*
C50	5.12 a
Fb100	4.18 bc
New 1:1 IC	4.48 b
Old 1:1 IC	3.86 c

CONCLUSIONS

The lower SR and Cmin registered in the IC demonstrated its ability to enhance C sequestration and reduce C footprint of agriculture.

Inorganic N and P fertilization did not enhance Cmin and SR at the applied rate. However, the combination of cereals + legumes and the incorporation of atmospheric N by the latter could influence Cmin suppression.

There is a long way to go in the challenge of reducing C dioxide emissions in agriculture using agroecological practices, such as intercropping, which not only provides C sequestration but multiple ecosystem services.

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