Intercropping with legumes to improve productivity and soil health

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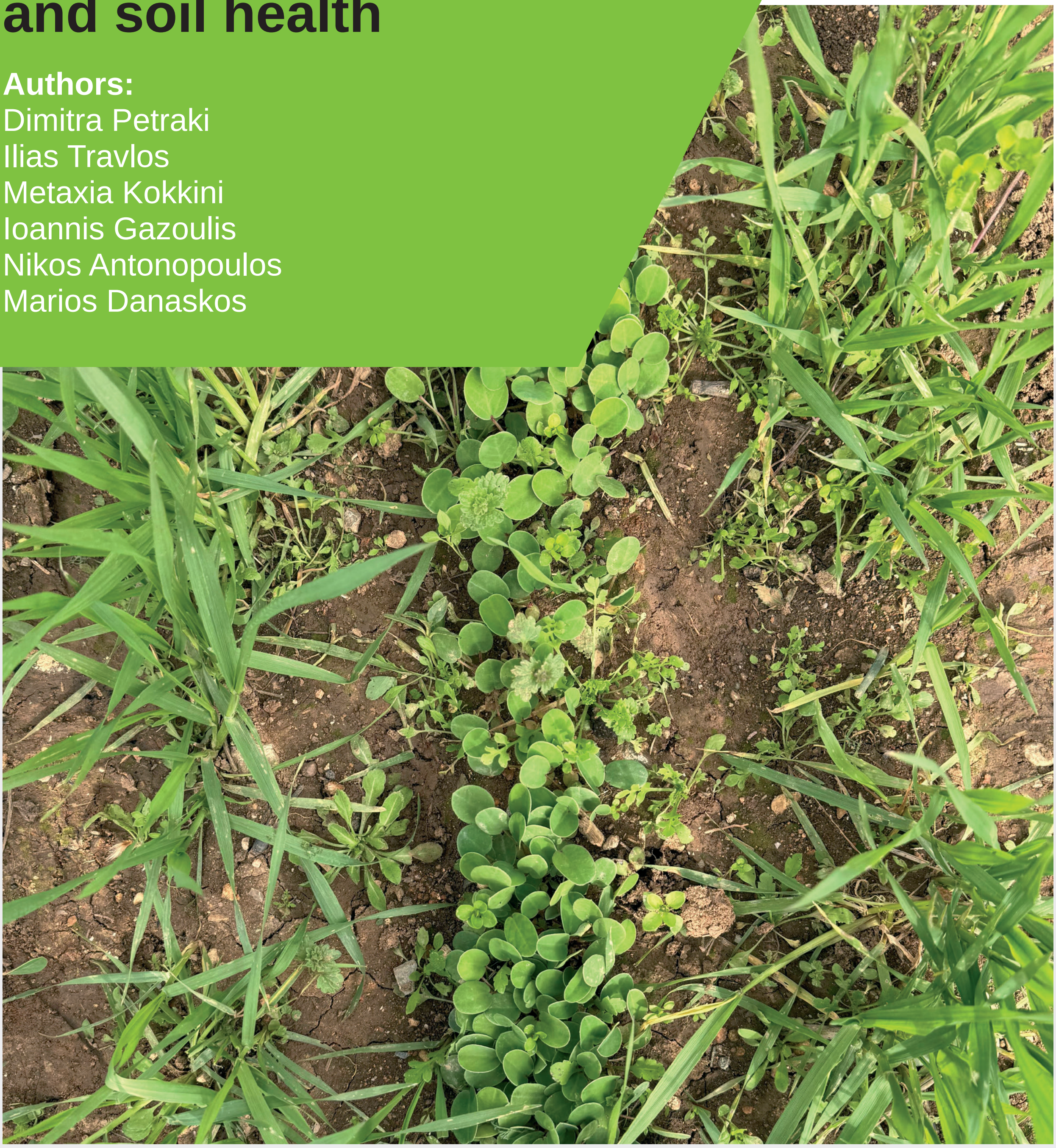

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Introduction

Intercropping is a cultural practice, where two or more crop species are grown simultaneously in the same field during overlapping growing seasons. There are four main types of intercropping: row-intercropping where crops are grown in distinct rows, mixed- intercropping involving crops grown without distinct row arrangement, strip-intercropping featuring crops cultivated in multiple-row strips and relay intercropping entailing sequential planting of crops with overlapping growth phases. The system generally integrates a main crop, usually cereal or cash crop, with a secondary crop, often a legume, that provides complementary ecosystem services. In cereal–legume intercropping, important cereals are often paired with grain legumes. For example, maize is commonly grown alongside soybean and wheat with field pea. In addition to cereal–legume combinations, intercropping can also involve two legume species, either annual or a mix of annual and perennial types. Such mutual legume intercropping enhances forage yield, improves nitrogen use efficiency, and contributes to weed suppression and system resilience. For instance, pairing red clover with pea or combining faba bean with grass pea has shown promising results.

Enhancing agricultural productivity through legume-based intercropping

In these systems, legumes represent a key functional group due to their unique biological properties and agroecological benefits.

Legumes convert atmospheric nitrogen into a plant-available form through a symbiotic relationship with rhizobia in their root nodules. The fixed N can benefit non-legumes in intercropping systems or serve as a nutrient source for subsequent crops in rotational systems. The resulting nitrogen enrichment benefits the associated non-legumes and improves soil N pools in the soil, leading to high yields. Therefore, the presence of legumes can reduce fertilizer inputs and nutrient leaching into groundwater. Beyond nitrogen, legume-based intercropping systems further optimize resource use compared to monocultures and increase the resilience of the cropping system.

Legume-based intercropping to enhance soil health and biodiversity

Furthermore, intercropping with legumes provides many additional benefits to soil health and quality by reducing soil erosion, improving soil processes, increasing moisture retention, maintaining soil fertility, increasing nutrient cycling, enhancing soil conservation, and suppressing weed infestation.

These advantages are further enhanced when legumes are intercropped with cereals, as their complementary root-zone interactions improve soil structure, the deeper root systems of legumes break up compacted layers, improve soil aeration, and promote stronger soil aggregates. Conversion from traditional monocultures to diversified cropping systems can further enhance carbon sequestration by maximizing biomass production and soil organic matter accumulation. Moreover, legumes can enhance microbial abundance and activity, which also contributes to improved soil health. In addition to soil health, incorporating legumes in intercropping systems increases the efficiency and resilience of agricultural systems while promoting soil and plant biodiversity. Many species from the Fabaceae family rely on animal-mediated pollination, providing floral resources such as nectar and pollen that attract a wide range of insect pollinators, and thus improve the overall productivity of the intercropping system.

The role of legumes for climate change mitigation

Beyond the ecological and agronomic benefits, intercropping systems with legumes also play a vital role in climate change adaptation. By reducing reliance on synthetic nitrogen fertilizers, legumes have the great potential to reduce greenhouse gas emissions such as carbon dioxide (CO_2) and nitrous oxide (N_2O) compared to conventional agriculture with mineral N fertilization. At the same time, the increased carbon sequestration in the soil plays a crucial role in efforts to mitigate climate change. By diversifying cropping systems and enhancing soil microbial biomass, legumes contribute to more resilient agroecosystems that are better able to withstand climate variability and disturbances. Notably, certain legume species, especially when associated with rhizobia, help to break down pollutants and remediate contaminated soils, thus indirectly contributing to climate-friendly land management.

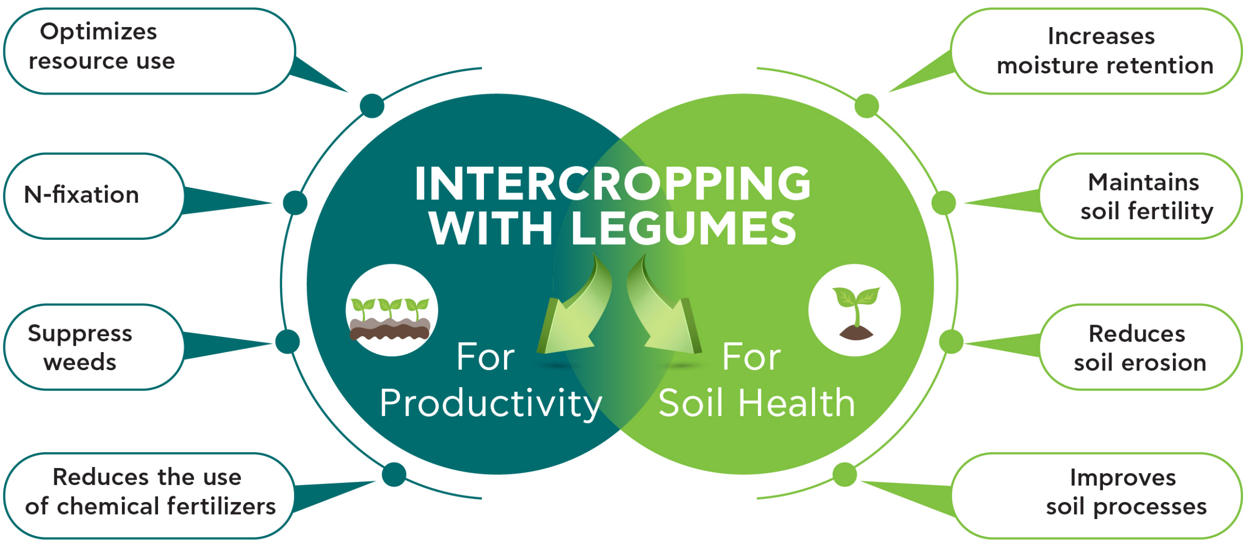

Figure 1.

Ecosystem services provided by legumes in an intercropping system, highlighting contributions to productivity enhancement and soil health improvement.

Conclusion

Legume-based intercropping systems offer a sustainable and effective approach to improving low-input agroecosystems. By naturally incorporating nitrogen through biological fixation, these systems reduce reliance on synthetic nitrogen fertilizers, minimizing the environmental damage associated with nitrate leaching and nitrous oxide emissions. Intercropping legumes and cereals is rooted in the principles of environmentally friendly agriculture and improves not only soil health and biodiversity, but also the nutritional quality and yield of forage crops, particularly through higher protein content. This practice also promotes higher productivity and profitability per unit area compared to monocultures. By improving the nitrogen cycle, reducing fertilizer and pesticide use and increasing crop resilience, legume intercropping is proving to be a powerful strategy for improving agronomic performance and environmental sustainability.

Figure 2.
Row-intercropping of sulla (*Hedysarum coronarium*) and wheat (*Triticum durum*).

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