



HAL
open science

Improving relay intercropping of service crops in cereal systems to cope with climate change

Florian Celette, Mathieu Rouge, Olivier Duchene

► To cite this version:

Florian Celette, Mathieu Rouge, Olivier Duchene. Improving relay intercropping of service crops in cereal systems to cope with climate change. 2nd K(C)lever cover cropping symposium - cover crops and belowground processes, Rhine-Waal university of applied sciences, Oct 2024, Kleve, Germany. hal-04757644

HAL Id: hal-04757644

<https://isara.hal.science/hal-04757644v1>

Submitted on 29 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Improving relay intercropping of service crops in cereal systems to cope with climate change

CELETTE F., ROUGE M., DUCHENE O.

Agroecology and Environment Research Unit, ISARA, 23 rue Baldassini, Lyon Cedex 07 - France

Introduction

Introducing service crops into rotations promotes ecosystem services, but these services are highly dependent on the production of biomass by the service crop (Vrignon-Brenas et al., 2016b). Relay intercropping into winter cereal makes it possible to limit economic risk thanks to minimal competition with cash crops (Gardarin et al., 2022), but sowing the service crop into an established crop is not straightforward. It may hinder its establishment and the provision of services (Vrignon-Brenas et al., 2016a). Complex interactions between cash crops, companion crops, weeds, and various soil and climatic conditions inevitably lead to uneven success (Vrignon-Brenas et al., 2016a). Therefore, the work presented has two objectives, based on two analysis approaches: 1) identify critical success factors based on 15 years of on-farm experimentation, 2) experiment and evaluate the relevance of the specific establishment practices of a legume service crop mentioned and used by innovative farmers.

Material and methods

To identify the key factors to succeed in the establishment of the service crop, we used a database gathering 46 on-farm trials settled in the southeastern part of France between the years 2008 and 2023. Most of them were organic (39), while others were in transition to organic (6) or conventional (1). In these experiments, red or white clovers were sown as service crops (SC) and put into a winter cereal (WCC) at the end of winter. 1048 quadrats of 0.25m² sampled at cereal crop harvest were compiled. Cereal, service crops, and weeds (W) dry biomass were measured at cereal harvest. A Hierarchical Clustering on Principal Components permitted to determine typical groups of situations. Other data were collected, such as crop and weed density at cereal flowering, soil, and climate parameters, and crop sequence and management. A multivariate regression tree (MRT) was built to explore how these data explained SC biomass variability.

In parallel with this work, we interviewed about 45 inspiring farmers and experts with experience in the relay intercropping of service crops. We identified the main lock-in farmers were facing and the rationale that innovative farmers developed to act and overcome some of these lock-ins. Afterward, on-farm experiments were designed with volunteer farmers to test some of the identified techniques in different agricultural, soil, and climate conditions. 16 experiments were implemented in 2 years, mainly focused on service crop establishment and services evaluation. 2 main factors were crossed: 1/ service crop species and 2/ sowing methods leading to 7 to 10 experimental plots per field. Sowing methods principles were common (1/ broadcast sowing (BS), 2/ BS + harrowing (BSH), and optional 3/ row seeding (RS)). The density, biomass, and nitrogen content of cash crops, service crops, and weeds were monitored from service crop sowing to the next crop harvest. In the same period, soil water and nitrogen dynamics were also observed.

Main results

Based on the 46 on-farm trials, the results were gathered into 4 statistical groups (G1 to G4) of situations. G1 represents situations where WCC biomass is high (12.8 T DM/ha) and largely dominant, preventing W and SC from growing (respectively 0.3 and 0.1 T DM/ha on average). In the other groups, WCC biomass is much lower (mean dry biomass of the group of 7.1, 7.7, and 6.2 T DM/ha in G2, G3, and G4, respectively). G2 gathers situations where growth conditions appear constraining and total (WCC+SC+Weeds) biomass production is low. G3 situations presented high SC biomass (1.9T DM/ha) and reduced W biomass (0.2T DM/ha). G4 situations are the exact reverse, with a high biomass of W (3.6T DM/ha) and almost no SC (0.1T DM/ha). The latter gathers a few situations (n=54), mainly corresponding to one field trial. MRT suggests that, except in some rare instances where climate conditions are especially favorable, SC biomass is essentially penalized first by WCC higher biomass and clover density at wheat flowering lower than 250pl/m² (n=667). Rainfall accumulation and fine soil texture appear favorable for this SC density, provided that W infestation is controlled.

From the 16 experiments dedicated to different establishment practices of the service crop, we observed that the mean emergence rate of service crops was low (~20%), and, in most cases (12/16 fields), sowing of red clover (cv. Lestris-RC) led to a faster and denser establishment (183pl/m² at wheat flowering) compared to white clover (cv. Melifer-WC, with ~108pl/m²; p-value<0.01). WC also led to lower mean biomass production at wheat harvest (125kgDM/ha vs. 300kgDM/ha; p-value<0.01) and higher risk of failure (almost 50% of WC treatments presented no clover biomass vs. 30% for RC). The mixture of red (50%) and white (50%) clovers (MC) presented intermediate emergence and biomass production. Harrowing after broadcast seeding (BSH) significantly improved the emergence rate of the clover. RS permitted an increase in the rate of emergence of RC but not WC. WC tiny seeds were not adapted to some seeders used, making it very difficult to control WC sowing density. Yet, WC survival was significantly increased with RS.

Main Conclusions

Competition with WCC appeared to be the first cause of SC failure. The value of WCC biomass penalizing the SC corresponded to highly productive organic conditions or conventional situations. It suggests that these relay intercropping techniques are poorly adapted in such conditions, at least without changing WCC sowing (e.g., interrow width) and without considering potential problems of herbicide residues. White clover, favored by farmers who wished to limit competitive interactions with the cash crop, was mainly found to be less successful than red clover since white clover was too sensitive to radiation limitation (Frame, 2005). Farmers and experts supported the idea that service crop sowing must be cared for. Broadcast seeding of service crops, primarily used by farmers, clearly underperforms in our on-farm trials network, but subsequent harrowing significantly improves the service crop establishment. Some interviewed farmers suggested RS as a way to reduce sowing failure strongly, but others feared potential damage to the cereal.

References

- Frame, J., 2005. Forage Legumes For Temperate Grasslands. FAO.
- Gardarin, A., Celette, F., et al. 2022. Intercropping with service crops provides multiple services in temperate arable systems: a review. *Agron. Sustain. Dev.* 42, 39. <https://doi.org/10.1007/s13593-022-00771-x>
- Vrignon-Brenas, S., Celette, F., et al. 2016a. Biotic and abiotic factors impacting establishment and growth of relay intercropped forage legumes. *Eur. J. Agron.* 81, 169–177. <https://doi.org/10.1016/j.eja.2016.09.018>
- Vrignon-Brenas, S., Celette, F., et al. 2016b. Early assessment of ecological services provided by forage legumes in relay intercropping. *Eur. J. Agron.* 75, 89–98. <https://doi.org/10.1016/j.eja.2016.01.011>