Yield prediction of cereal-legume intercrops: from data gathering to modeling

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Diversification & Digitalisation
Trends that Shape Future Agriculture

BOOK OF ABSTRACTS

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Welcome to XVII. European Society for Agronomy Congress – Diversification & Digitalisation – Trends that Shape Future Agriculture

Dear Friends,

it has been two and a half years, since many of us have been participating in a scientific congress, as we have done so many years before, meeting other fellow scientists, old friends and the new kids on the block, and enjoying being in another place for a couple of days, with different habits, food and landscape. It has always broadened our minds, and we always learned new aspects of agronomy when visiting experiments and research facilities during the mid-congress excursions, as it was a well-appreciated custom during the Congresses of the European Society for Agronomy.

The Covid-19 pandemic has changed our lives, and also the modes of communication in science. Being forced to meet virtually in the aether, we experienced the first online Congress of the ESA in 2020. It worked, surprisingly well, and with the technology getting better and better, and the pandemic losing its evil face, we are now in the comfortable situation to choose whether we take on travels for a meeting, or quickly meet online, saving kerosene and time otherwise being lost at airports or in traffic jams.

Now we are back in 3D. The seventeenth congress of the European Society for Agronomy (ESA) will be held in Potsdam, Germany, from 29 August to 2 September 2022, and an overwhelming majority of you voted for having a "physical" congress, longing for all those side effects that we have been missing in the virtual world. And there is a lot of things we need to do: with yet another heat record this summer, climate change becomes undeniable for almost all of us. At the same time, more and more studies suggest a negative impact of chemical substances being used in agriculture on biodiversity, and the decline of insects and birds in European landscapes has alarmed policy-makers. The eutrophication problem also still is far from being solved. Mitigation of and adaptation to climate change, while reducing the use of agrochemicals and further increasing the efficiency of the resources used requires new ways of thinking. And it is our task, the agronomists and agricultural scientists, to develop this new thinking, with fresh ideas, new evidence and practical solutions. The digital world offers completely new approaches, and technological support we have never dreamt of. And on the other side, our ancestors have optimised their cropping and farming systems over millennia through diversification, and much of this knowledge is still very useful. But how to make best use of it? How to integrate the many ideas, so that all the multiple goals can be achieved in a well-balanced way?

The XVII Congress of the European Society for Agronomy is *the* place to exchange on all this. I hope that you all find an interested audience for your research, and learn many new things from your peers that inspire your future work. Have a safe journey to and fro, and …

Enjoy your time in the beautiful town of Potsdam!

Yours

Claas Nendel
ESA President

Yield prediction of cereal-legume intercrops: from data gathering to modeling

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Intercropping; Modeling; Data

In crop science, mixing two species in the same field (intercropping) has gained a lot of interest. Cereal-legume intercrops are a particularly promising mixture type and field experiments involving these intercrops have increased in the last decades. Gathering the results of these multiple experiments to gain knowledge on intercropping is a promising, yet uncommon, approach. Indeed, observing crop species responses to various soil and climate conditions is necessary to generalize the results obtained in single locations and to enable the development of predictive approaches of crop performance. However, experimental results produced for different goals are heterogeneous and combining them is challenging, because of diverse experimental designs, samplings, measured features, and data format (Pappagallo et al., 2021).

In this study, we describe the workflow that we have conducted to face the challenges arising from the gathering of heterogeneous experiments to the building of predictive models of intercrop yield.

We gathered results from 35 factorial experiments in diverse environmental conditions (5 locations x 15 years, 8777 observations). Main crop features (yield, height, shoot biomass) were collected in intercropping and sole cropping conditions. We first developed an R package to combine experimental data, used a single data format and versioning to track modifications caused by data curation. To face the heterogeneous sampling across the experiments, we used smoothing splines to fit the growth dynamic of height and shoot biomass, from which we derived key features of plant growth dynamic (i.e. maximum growth rate, lag phase).
Our goal is to predict intercrop yield as a function of plant-plant interactions, environmental variables and agronomic practices. For plant-related features, we focused on a set of predictors rather than using all available data, mobilizing concepts from community ecology. For instance, differences between crop features within the intercrop (cereal-legume) can be a proxy for plant-plant interactions (competition / complementarity). Plant-environment interactions were estimated through the computation of nitrogen nutrition index, adapted for intercrops (Louarn et al., 2021). For environmental variables, we seek to compare different approaches (classification of similar environments based on the sole crop reference, computation of rough climatic indicators, functional data analysis, etc.). This former step will allow us to reduce the dimensionality of climate and soil variables and to obtain a set of environment-related predictors.

We seek to use these two sets of predictors to build machine learning models. Until now, we have built models based on 3 algorithms (boosting, random forest, LASSO regression)

including plant-plant interactions predictors and some agronomic practices. Our preliminary results, based on these models, are encouraging, on both training and evaluation data sets. These results tend to indicate that the difference of maximal height was often a good proxy for the legume's yield in many mixtures. Differences between maximal growth rates seem also to strongly influence the outcome of intercrops. The predictive ability of our models is affected by the combination of species and by the output variable predicted (yield of the legume seems to be harder to predict). Next steps of our work include i) the use of environmental variables as new predictors, ii) fitting other model types (support vector regression, mixed models, etc.) and iii) evaluation of robustness of our models via stratified cross validation techniques.

Louarn et al., 2021: Plant nitrogen nutrition status in intercrops– a review of concepts and methods
https://doi.org/10.1016/j.eja.2021.126229

Pappagallo et al., 2021: Coordinating data collection in intercropping: A feasible example