Assessing the potential of crop model to reproduce Thinopyrum intermedium agro-ecosystems functioning and support knowledge acquisition about perennial grain crops.

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Perennial crops are gaining increasing attention in recent years as they are proposed as a potential solution to address several challenges encountered with annual crops productions in the global context of agroecological transition. Indeed, it has been promoted to enhance carbon storage, microbiological activity and it could prevent issues such as fertilizing nutrients leaching or soil erosion. Worldwide, several selection programs are thus taking place to develop perennial crops or to create perennial versions of annual cereals (such as rice, rye and wheat).

Regarding perenniality and grain production, one of the best foreseen candidates to produce perennial grain is Thinopyrum intermedium ((Host) Barkworth & D.R. Dewey), commercialized under the name of Kernza®. Its recent selection history is notably turned towards the increase of thousand kernels weight and the ease of threshing. Additionally, its original use as a forage crop makes it possible to consider a dual purpose of grain and fodder production during the same cropping year. The emergence of this relatively new crop brings now questions and challenges regarding its management practices, its impact on soils and agronomic potentials or its integration into current cropping systems.

Crop modeling is a powerful tool used in support of field experiments to improve our understanding of plants physiology, to test new technical itineraries or to assess crop response toward climate change. Developing relevant models remains important to accelerate and support knowledge acquisition about these new crops as well as assess their potentials, limitations and improvement path.

The mechanistic STICS crop model was chosen to simulate Th. intermedium growth and development because of its proven ability to simulate various plants including wheat, vine, forage grasses or tomato. Due to the original behavior of Th. intermedium as a grassland producing grain, the plant was simulated using similar formalisms as the ones used for annual cereal crop. The perenniality of the plant was simulated by an external algorithm which kept values of state variables from the end of a simulation and use them as starting values for the next one. Field data were collected under Belgian conditions (temperate area, deep loamy soil) during 4 years and under multiple fertilization management schemes. After a parametrization and a calibration/validation process, the model showed very good results regarding the simulation of phenology, biomass production, grain yield and nitrogen nutrition.

Multi simulations were then run over twenty past meteorological dataset in order to determine the optimal nitrate fertilization scheme for the crop. Results showed that a total application of 100 kgN/ha separated in two fractions allowed to maximize high grain yield probability. A first fraction should ideally be applied at the stem elongation stage with an amount of 75 kgN/ha and a second during autumn, with an additional amount of 25 kgN/ha. These results are consistent with the findings of Jungers et al. (2017) who showed that an application of nitrogen fertilizer in the form of urea at rates ranging from 60 kgN/ha and 100 kgN/ha in spring allowed to achieve the best yields by maximizing fertile tillers. These early results are encouraging and support the idea that crop modeling can be a powerful tool to support and accelerate knowledge acquisition about these new types of crops.

Further investigations will be done in order to evaluate the robustness of the model in various agroclimatic regions. In addition, new formalism will be tested regarding the modeling of bellowground biomass dynamics.

References

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