Cereal–Legume Intercropping

Subjects: Agriculture, Dairy & Animal Science

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With the current objective of moving away from monoculture and the development of the "ecological intensification" of agrosystems, the cereal-legume intercropping takes advantage of the symbiotic relationships that the legume develops with soil micro-organisms (rhizobiums). Legumes are capable of fixing atmospheric nitrogen thanks to the nodules of its roots, and thus provide to this crop a part of its nitrogen needs. The choice of species and the proportion of grains to be sown are determined by the objectives of intercropping. For human food, simple mixtures are favoured (e.g. wheat/pea, barley/bean, triticale/pea). For fodder production, the number of species can be higher.

Intercropping, cereal, legume

1. Principles and Benefits

Contrary to monoculture based essentially on chemical inputs, genetic selection, shortening of rotations which causes significant damage to the ecosystem (pollution, loss of biodiversity) [1], the cereal–legume association is of great interest in terms of increasing biodiversity in the field [2]. This association represents an agroecological practice based on the biodiversity of a multispecies system that reintroduces synergistic effects between plants and other regulatory mechanisms promoting resilience of the agroecosystems and ecological sustainability [3][4].

Cereal–legume intercropping using crops promotes ecological intensification while it: (i) ensures quantitative dry matter yield equivalent to that produced by the same two pure crops; and (ii) increases protein yield and reduces nitrogen fertilization [5]. The symbiotic relationship between the legume and the bacteria housed in the nodes of its root system enables the plant to fix atmospheric nitrogen, thereby allowing it to meet its nitrogen nutrient requirements. Due to the high competitiveness of cereals in terms of nitrogen uptake and the sharing of soil with legumes, cereal can benefit from the natural nitrogen supply released by legume roots [2][6][7]. For farmers, interest in this system is twofold: (i) reducing nitrogen inputs and production costs while (ii) ensuring production with less pollution, since the mineral nitrogen typically used in conventional agriculture is very leachable. The competitiveness of cereal crops in terms of nitrogen absorption allows them to capture residual mineral nitrogen from previous crops, whereas the symbiotic fixation of atmospheric nitrogen by legumes provides a cleaner resource for its needs while helping to meet the nutrient requirements of its partner [8–11]. Some studies [8][9] have shown that the natural N input associated with mineral N supply can be an important technical lever to control the yield of the cereal–legume intercropping. Finally, the residual organic matter of this system, which is proportionally richer in nitrogen compared to monocropping, can help to replenish the soil's mineral reserves and, thus, preserve its natural fertility [10][11][12][13].

The best complementarity observed between cereal and legume is that of nitrogen, which is achieved through the optimal use of soil mineral nitrogen (by cereal) and fixed nitrogen (by legume) in their different growth cycles, thereby leaving fewer resources for weed development. The cereal, which is already more competitive in its use of mineral nitrogen, impulses the legume to fix more atmospheric nitrogen by symbiosis to meet its needs, which hinders the development of weeds due to the lack of nitrogen resources [14][15]. Another factor that can explain the reduction of weeds and infectious diseases in intercropping is allelopathy, which is the direct or indirect biochemical interaction between associated plants to inhibit weeds or pathogens [16][17][18][19].

Thus, the intercropping meets not only the need to reduce chemical inputs (fertilizers and phytosanitary products) and their associated production costs but also the need to secure yields to address interannual variability [20][21][22] The better quality of cereal (e.g. wheat) produced in intercropping with legume can also have economic benefits for farmers by increasing the protein rate. In organic farming, the production of common cereal (e.g. wheat, barley) is more valuable on the market due to its high protein content. However, nitrogen input is the main factor limiting this highly sought-after qualitative performance [23]. To remedy the lack of mineral fertilization in organic farming, the intercropping of common cereals with legumes is an interesting technical and economic alternative [24].

2. Challenges and development paths to Cereal–Legume Intercropping

Beyond highlighting the agroecological and economic benefits linked to crop diversification through cereal–legume intercropping, this entry calls attention to the literature suggesting that the structuring of the value chain around cereal–legume mixture products faces a set of technical (i.e., varietal selection, phytosanitary problem control, driving of the agroecosystems, collection and storage management), economic (i.e., cost, prices, market opportunities, and contract relationships), and public policy (i.e., incentives provided by public subisidies) obstacles that contribute to its slow adoption and dissemination in the European context. The dynamics of the production as well as the temporal, spatial, and logistical organization of pure crop value chains (cereal and legume) do not ensure the spontaneous integration of new intercropping products on the market. This can be explained by the fact that all economic stakeholders (i.e., producers, collectors, and processors), as well as technical and scientific support stakeholders, define their strategies according to the requirements of the conventional crop market.

The implementation of some critical levers at different levels of the value chain may unlock the system. The scientific and technical research to improve the effeiciency of the interprocropping system as well as the developement of niche markets for plant proteins and labeled products of high environmental value provide an impetus for the development of the cereal legume intercropping. The new value chains must valorize its competitive advantages—particularly its ecosystem benefits and higher product quality—to assert its place in the market and build a sustainable value chain. This entry defines priorities that must be addressed by all stakeholders in the cereal–legume value chain to focus on significant issues and solutions to accelerate the adoption and dissemination of the intercropping system.

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