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HOW COULD LIVESTOCK FARMING MAXIMIZE ORGANIC PRODUCTION AT A GLOBAL SCALE?

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Abstract: Organic agriculture is questioned about its ability to feed the planet. The place of livestock appears to be central to the debate, particularly because of the role it should play in cropping systems to close mineral cycles and control diseases, weeds and pests. However, its feed efficiency is low. In the end, it appears that the place of livestock in systems based on the principles of agro-ecology and particularly in organic farming will be determined by its ability to use fodder resources from cropping systems or permanent grasslands on the one hand, and resources from crops that cannot be used by humans on the other. The optimum importance of livestock in farming system and territories will therefore depend on each context but should lead to maximizing food production for populations

Introduction: Providing sufficient food and equilibrate diets for a growing population while curbing the environments impact caused by intensive agricultural systems represents a key challenge for the future. Albeit organic farming (OF) is often proposed as a promising sustainable alternative to current agricultural systems, its ability to feed the world is highly contested due to its lower productivity compared to conventional farming. At the same time livestock production has been under fire due to its environmental impacts -like GHG emissions, land use and water footprints, and due to the low efficiency in transforming feed into edible animal products (Poore and Nemecek 2018). However, livestock plays a key role in organic systems by closing the nitrogen (N) cycle and transferring N from grasslands to croplands. Here, we propose a framework for discussing solutions to this possible wicked problem. It is raised for organic agriculture but more broadly for systems based on the agroecology principles

Material and methods: This work is based on a reflection on the challenges of a large-scale conversion of OF. It is conducted on the basis of bibliographic references

Results: Livestock and organic farming: challenges and opportunities

Forage crops and livestock have a key role in cropping systems and the global N cycle

Because of the ban of chemical fertilizers and pesticides, an expansion of OF will require more diversified crop rotations to control weeds, diseases and pests, and to enhance N availability in soils through the biological N fixation operated by legumes. The introduction of forage lays, most often legume-based, have a key role to play in this strategy. Given the relatively high transport and dehydration energy costs, on the farm use of such fodders by herbivores would represent a key asset towards crop-livestosk farming systems with the additional advantage of enhancing N cycles via animal excreta at the farm level. Indeed, livestock plays a key role in managing N cycling in organic systems. In particular, herbivores are able to transfer N sourced from grasslands towards croplands through their manures. This is especially important because an expansion of organic systems may lead to a structural lack of N resources in cropping systems. Barbieri (2018) showed that N deficiency would be a major limiting factor for organic production in a full organic world, leading to an overall -36% reduction in global food availability. However, a conversion shares up to 60% would be feasible, in coexistence with conventional farming, when coupled with demand-side solutions such as the reduction of the per-capita energy intake or food wastage.

Herbivores efficiently transform resources that are not edible to humans

Herbivores can transform these forage resources into protein-rich foods, either as meat or milk, albeit their efficiency in transforming fodders' protein into food protein is low. Ratios between livestock ingested proteins and human-edible produced proteins of ~25 has been reported for beef production, while better values (~5) reported for dairy production. This ratio drops even more when monogastric animals are considered (~4.3 for pigs and ~3 for broilers) (Wilkinson 2011). These levels are better than for herbivores but monogastric feeding competes much more with human food consumption.

In addition to fodders, livestock could also enhance the use of co-products that are non-edible for humans (Ertl et al. 2016). For instance, cereals have a share of edible energy that varies from 63 to 74%, while the remainder (bran, etc.) can still be used as feed. Monogastrics in particular may play a role also by efficiently using food wastages as feed, thus enhancing circular economy management strategies. However, the use of such resources require strict safety tests for contaminants.

Livestock production systems also provide several ecosystem services

It is important to remember that livestock management provides many additional services. The challenge is to maximize the services provided by livestock while limiting its competition for the use of edible resources (Dumont et al. 2019). Grassland-based systems and integrated crop-livestock enterprises that are common in organic systems are essential to preserve a wide diversity of permanent grasslands and hedgerows in temperate-climate regions, where forest is the climax vegetation. Preserving such ecosystems is essential due to their role in soil carbon sequestration, biodiversity and landscape conservation. In addition, livestock production has key role in providing cultural and socio-economical services such as gastronomy, territorial vitality, economic security of farms as well as energy supply, e.g. animal traction.

Discussion: According to current knowledge, sustainable farming systems often come with decrease in productivity compared to the current most intensive farming activities. A consensus exists in identifying the several possible ways to achieve both sustainable farming and global food security. It consists in limiting food losses and wastage, implementing agroecological practices (including diversification of production), and dietary changes involving a reduction of animal food consumption (Erb et al. 2016).

Exploring medium and long-term scenarios involving such changes at the global scale is an exercise that does not have a unique solution, especially when demographic and climatic changes area accounted. The answer is context-dependent, in particular in relation to soil agronomic potential. In the Netherlands, Van Kernebeek et al. (2016) concluded that the most efficient land use scenario would be achieved if 12% of human protein intake was supplied by livestock products. Evidences that current protein consumption in Europe is much higher than nutritional recommendations has been reported by the TYFA project (Poux and Aubert 2018), including a 60% surplus for animal proteins. The TYFA project shows that overcoming the use of any chemical agricultural input while feeding the European population would be feasible given a significant 17% and 45% decrease of protein consumption and livestock production, respectively. These changes are key to ensure sufficient food supply despite a 20 to 45% drop in crop yields. In addition, thanks to this decline of livestock densities -especially ruminants- together with the hypothesis to ban any synthetic N fertilizers, GHGs emissions would drop by 40%, a result in line with the work of Poore and Nemecek (2018).

Despite the success of such studies in identifying a balance between crop and livestock production at the global scale, optimal interactions between animal and plant production relay on accurate biological mechanisms that must be analysed at finer scales, i.e. at the farm or territorial level. Agroecological and organic farming systems point out how optimizing the synergies between animal and plant production is a promising way for a transition to modern and ecological food systems. Beyond agronomic optimization, several question associated with organisational aspects -e.g. how to replace animals in crop-specialised landscapes- have to be answered. Answering such questions should start from individuating the relevant public policies (territorial planning, public agricultural aids, nutritional policies), as well as any policy regulating land uses in competition with food production

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