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Engaging Farmers in Climate Change Through Assessing Intercropping

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Summary

Agriculture is one of the most vulnerable and adaptation-prone sources of livelihood facing climate change. Joint adaptation planning by farmers and researchers can help develop practically feasible and environmentally farm adaptive capacity. Here, the perceptions of farmers regarding intercropping, the cultivation of two or more crop genotypes together in time and space, as a means to prepare for climate change. The main challenges associated with intercropping were related to the lack of information on crop variety performance and optimal yielding in mixtures, more complicated crop management and harvesting, and the economic risks associated with experimenting with novel mixtures. Therefore, this paper is aim to raise awareness on the potential of intercropping for addressing climate change-induced cropping challenges in northern agriculture.

Keywords: climate change; ecological intensification;intercropping; legumes; yield security.

Introduction

Agriculture is a major land use, using approximately 38% of the global land area. Climate change impacts agriculture by the need to develop existing practices, including field cropping, to minimize greenhouse gas emissions and thus meet the mitigation targets for climate change. Farmers must adapt to the impacts of climate change to secure sufficient food production for the growing world population. Sustainable intensification, i.e., increasing productivity from existing agricultural lands while minimizing the negative environmental effects and ensuring the future needs of food production, has been proposed as a central means to restrict further land clearing for agriculture and transform agriculture and food systems to operate in a more sustainable way. Both climate change mitigation and adaptation relate to the main resources used in agriculture: land, carbon and nitrogen, water and energy, which provide good potential for synergism in the solutions (Smith and Olesen, 2010).

Developing 'climate-smart' solutions for agriculture refers to adopting practices that benefit both mitigation and adaptation, while ensuring the productivity and resilience of farming, including the economic aspects (FAO, 2016).

Intercropping represents a within-field diversification strategy that is based on ecological intensification. It refers to the cultivation of two or more crops together in time and space, and it is an ancient practice of cropping that aims to maximize productivity per land area using only few external inputs. The method allows for designing local genotype combinations and intercropping types (mixed, relay, strip or row) to target various goals, which makes the method interesting to be developed and employed more as a means of sustainable agriculture. Overyielding per land area is one of the often-reported benefits of intercropping, and it is potentiated by the enhanced utilization of growth resources: growing space, water, nutrients and light (Vandermeer, 1992). Diverse crop genotypes compete less with each other than identical genotypes. Leveraging ecosystem services such as the biological fixation of nitrogen and facilitative interactions such as the associational resistance to pests and pathogens reduces the use of agrochemicals in intercropping. Mixing genotypes may also stabilize yields and thus contribute to food and feed security.

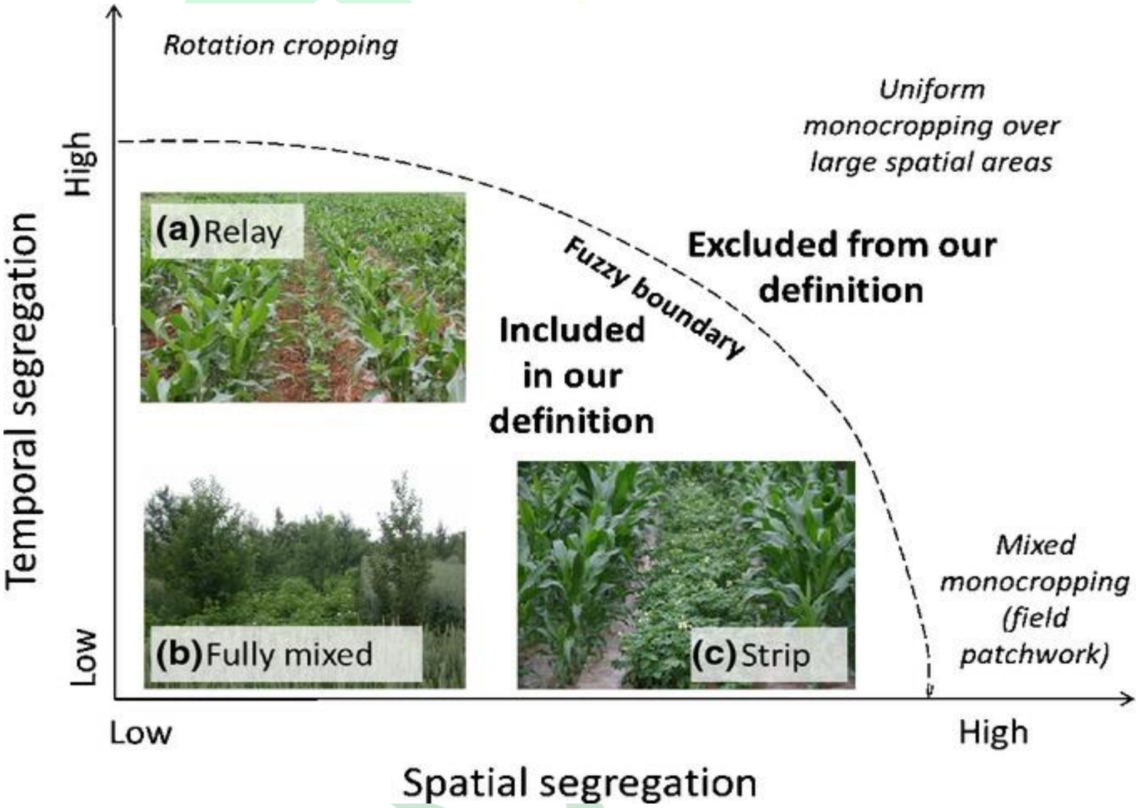
Potentials and Challenges of Intercropping

Perceived potentials of using intercropping related mostly to crop production and farm economy, with additional social and environmental aspects. Intercropping was regarded as supporting self-sufficiency for protein and nutrients, improving soil quality and water regulation, advancing novel genotypes and allowing the reduced use of external inputs. The potential to reduce workload was identified for certain types of intercropping, e.g., cover cropping. The recognized potentials of intercropping, albeit acknowledged to depend on the intercrops and the type of intercropping used, including enhanced yield security, soil conservation, regulation of water dynamics, buffering from pathogens, increased nutrient and protein self-sufficiency, and the reduced use of fossil energy-based external inputs, relate to addressing many climate change-related challenges for northern field cropping. Thus, intercropping can be regarded as both a targeted adaptive strategy of a farm, a potential climate-smart practice to be developed locally and context-specifically, and a means for enhancing farm adaptive capacity.

Maintaining and improving soil quality and fertility via intercropping was regarded as an important potential of intercropping in our workshop. Soil is a central resource of farms, and it relates to both climate change mitigation and adaptation actions. Earlier studies have reported how diverse and prolonged soil cover and shade can protect soil from weather extremes such as heavy rain or prolonged drought. Evaporation (water escaping into the air from bare soil) can be lower, and water use efficiency (water uptaken and transpired by the more dense canopy) can be higher with intercropping (Ray *et al*., 2015). Field water dynamics, including water use efficiency, runoff and excess water, are increasingly important when considering water budgets and yield under climate change. In intercropping, plants with differing root structures can take up water from varying depths, and adding deep-rooted or drought-resistant crop genotypes can reduce the between-crop competition for scarce water. Intercropping can induce root growth into deeper soil layers, as reported for, e.g., faba bean intercropped with wheat. Increasing species diversity (a 16-species mixture) was also found to increase the deep-root (roots below 30 cm) biomass seven-fold compared with monoculture plots. The extensive root biomass sequesters more carbon in the soil in carbon-depleted soils, especially in the deeper layers. The increased vegetation cover and reduced tillage, as potentiated by relay intercropping, can also impact greenhouse gas emissions during winter-time melting and freezing cycles.

Designing Optimal Intercropping

For the most promising intercrops to use in Finland, the participants listed crop species with the ability to biologically fix nitrogen (legumes), especially pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.) and clovers (*Trifolium* sp.). Clovers were emphasized as possessing the additional benefit of improving soil structure. Green manure mixtures including legumes and deep-rooted species were also rated important. Cereal farms, in particular, were perceived to benefit from having green manure mixtures and undersown crops to diversify their crop rotations. Designing intercropping is a knowledge-intensive process that combines scientific and practical expertise. As a first step, the knowledge on the potential of the method among farmers, advisers and the whole food production chain needs to be improved. Arbuckle *et al.* (2015) found that the adoption of cover cropping by farmers in Iowa was related to the gained experience of their benefits, the presence of facilitative educational and technological infrastructure, and the development of risk abatement strategies for intercrop trials. More farm-scale research, as suggested also by our workshop, should be conducted to assess the pros and cons of the method in practice and provide more detailed instructions on how to employ, leverage and develop the method. Many possibilities exist for practicing intercropping such that guidelines and better knowledge on how to select the best type of intercropping (row, strip, mixed intercropping), the species or variety genotypes to combine, adjusting the timing of sowing/planting and management and considering local and production-specific goals are obviously needed. Accessibility, i.e., the availability of the method to farmers is good because relatively little additional economic investments are typically needed, and in contrast, economic costs can be reduced via reduced input use (Vandermeer, 1992). As revealed by the challenges recognized for adoption of the method more broadly, the usability of the different spatiotemporal types of intercropping depends on the technological and educational resources of the farm, agricultural policies, the germplasm available by breeding and markets.



Advancing the Uptake of Intercropping

Intercropping was perceived to demand courage from farmers to consider sowing multi crops instead of traditional monocultures and to allow more agro ecosystem diversity, especially for the most common monocultures: cereal cropping. Forage mixtures and green manures are easy to adopt, and it was discussed that farmers have a high interest in experimenting with novel genotypes and mixture combinations. The selection of an available germplasm, breeding for good intercrop performance and the availability of seeds were found to be important in allowing experimentation with more diverse mixtures in mixed intercropping at farms. Under sown crops and green manure are easy to add to the crop rotations of specialized cereal farms, and their benefits for the soil structure and environment further supports their use. In addition, using intercropping to diversify might offer novel forms of collaboration between plant production and livestock farms and provide novel opportunities to produce feedstock for bioenergy use. The key traits mentioned as important in intercropping were biological nitrogen fixation, improvement of the soil structure by deep root systems, pathogen resistance and the crop properties related to health benefits in feed use. Both the quantity and quality (palatability) are imperative for producing feed, and optimally selected mixtures could improve both (Walker and Ogindo, 2003).

Breeding for optimal performance in mixtures, “adapting the crops to grow well together”, was an innovative suggestion made at the workshop. To our knowledge, intercropping performance has not been a central criterion for breeding to date. However, especially concerning the traits that are scarcely addressed in traditional breeding, breeding for optimal mixtures might provide alternative ways for advancement. Seed suppliers likely have an interest in the experimental mixing of the existing genotypes and the search for novel markets by diversifying their supply via more tailored products in a faster pace this way. However, for northern latitudes, the selection of crop genotypes to use is more restricted than for more southern regions, which partly reduces the combinations to be tested. The available germplasm obviously determines much of the potential to be gained by intercropping.

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