Agricultural plastics. Socioeconomic and ecological assessment of the use of plastic foil in asparagus production in Germany and resulting recommendations

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Summary

Using asparagus cultivation in Germany as a case study, the use of agricultural films and their effects on the environment and society are described. Based on a conflict-sensitive research design with literature review, discourse analysis, expert interviews and workshops, a description of the situation is presented that takes an integrative perspective on the production, use and disposal of agricultural films in order to identify approaches for improving the situation. From the multi-perspective understanding, various starting points for a (partial) re-design for the adaptation and redesign of cultivation methods using agricultural films as well as questions for policy, practice, research and development and for cross-sectoral solution efforts were identified in order to develop alternatives and minimise undesirable effects.

The topic is only a small part of the global plastic issue and only a share of various effects of plastic in the environment. The use of plastic in the front-end of agricultural and food value chains is an example of how the functions and effects of plastic need to be understood holistically as a complex problem. In detail, however, there are various gaps in knowledge about causes and scope, e.g. on the effect of nano- and microplastics in soil, the effect on biodiversity or the effect on plant and animal food quality and thus on human health. However, the state of scientific knowledge indicates that plastic is a global problem for planetary boundaries of material integrity.

Using asparagus cultivation in Germany as a case study, the use of agricultural films and their effects on the environment and society are structured and described. Based on a conflict-sensitive research design with literature review, discourse analysis, expert interviews and workshops, a description of the situation is presented that takes an integrative look at the production, use and disposal of agricultural films in order to identify approaches for improving the situation. From the multi-perspective understanding, various starting points for a (partial) re-design for the adaptation and redesign of cultivation methods using agricultural films and questions for policy, practice, research and development as well as for cross-sectoral solution efforts were identified in order to develop alternatives and minimise undesirable effects.

Conventional agricultural films made from fossil, non-biodegradable materials such as polyethylene affect the hydrothermal environment of the soil. This effect is used in cultivation practices to control soil water balance and soil temperature. These functions enable the planning of cultivation methods, farm development and organisation of markets and have therefore found wide application internationally. Asparagus cultivation is an example of the wide use of the functions of agro-plastics also for fresh regional food. Although it is a specialised area of agriculture, it is a paradigmatic example of the path-defining importance of the extensive

diffusion of the use of plastics in agricultural and horticultural production processes: through the use of film, from a niche product the largest area of vegetable production has developed with the highest farm value added in Germany.

Conventional agricultural films are tested in technical procedures (DIN EN 13655, DLG) that do not take into account the possible environmental impacts of their use and remainings in the environment, according to interview statements by experts. The regulatory framework does not sufficiently control the sector to avoid microplastic emissions and other undesirable effects before, during and after use. Due to the regulatory gap and lack of integration of disciplinary knowledge, actors on the ground actively try to avoid the issue or to find the more convincing arguments 'pro and contra film'. At the same time, an all-encompassing scientific evidence that also takes into account the diversity of individual farm conditions would hardly be possible. The functions of sustainable soil and crop cover thus become an innovation and transformation challenge for sustainable food systems in which sustainably produced fruit and vegetables are to play a major role. According to the authors of the study, the use of agricultural plastics should be handled in a differentiated manner as a matter of discretion in the sense of precautionary and circularity principles. The functions and effects of agricultural films generate a multiple dilemma situation between the production of healthy food, climate change, biodiversity and the material integrity of natural resources. Solutions can therefore not be developed exclusively according to a win-win or win-loose scheme. Rather, an integrative view of the various sustainability aspects and goals is necessary, recognising the complexity and absence of quick 'perfect' solutions. In front of the dynamically evolving state of knowledge, the team of authors therefore proposes different design strategies for short-, medium- and long-term approaches to improve the situation:

- Until better solutions are available, farms should be careful in the short term when spreading, moving and recovering conventional agricultural films, check the field and replace films in time to avoid plastic particles entering the soil. The requirement of residue-free film recovery should be a conditional criterion for manufacturers of conventional films and associated machinery (*design for material integrity*, short-term).

- The use of agricultural films should be reviewed and reduced to a balanced level in the short term, e.g. by limiting the covering time per year, the number of film layers over an area and the total size of the area covered with film - both within farms and across farms in a district. This development should be accompanied by research on the impact of film-covered areas in the agricultural landscape in order to be able to consider biodiversity impacts and farm development perspectives in a balanced way (*design for circularity, design for biodiversity*, short-term).

- Area-wide collection and recycling systems for agricultural films should be further developed in the short and medium term in order to avoid storage problems on farms. However, a prerequisite for this is a review of the possibilities for avoiding and reducing the use of conventional agricultural films (*design for circularity, design for material integrity*, short-medium term).

- A collection system is a prerequisite for circular solutions, for which, however, requirements for durability, recyclability and standards for application safety of recycled plastic products in the agricultural and food sector should be agreed in the medium term (*design for circularity*, medium term).

- The use of the functions of all agricultural films should be subjected to criteria and standards that are not only technically oriented, but also take better account of sustainability aspects for production, use and disposal. For this purpose, the authors of the study present different strategies for the design of production processes that have been using films so far, in order to address different aspects of planetary health. (*design for circularity, design for usability, design for material integrity, design for biodiversity, design for changed climate conditions*, medium to long term).

- Farm and production areas should be adapted to the habitat requirements of potential target species in a site- and crop-specific manner in order to promote biodiversity through agro-ecological measures such as the expansion and greening of inter-rows (*design for biodiversity*, short to medium term).

- Where possible, conventional agricultural plastics should be replaced by biodegradable materials. The basic prerequisite for this is that biodegradable materials are tested and introduced iteratively in the sense of the precautionary principle (e.g. standards and norms for effects on soil, ongoing accompanying research for long-term effects, organising learning and feedback loops). User requirements should be systematically considered, e.g. through strategies for timely moving and recovering and industrial composting of the material (*design for usability, design for material integrity*). When using biodegradable films, the conclusions on design for biodiversity should be taken into account (medium to long term).

- For such a preconceived reflexive innovation and supply system for the use of conventional and biodegradable agro-plastics, sufficient and comparable monitoring of the effects of the individual solutions - both within companies and across sectors as well as society as a whole - makes sense. In this way, not only horticulture could shape the previous multiple dilemma situation of the functions and effects of agricultural films as a field of action in the medium and long term in the sense of "planetary health" (*design as learning system for planetary health*, medium to long term).

Overall, the team of authors draws the following conclusions:

For all proposed short-, medium- and long-term starting points for a conscious approach to the functions and effects of agro-plastics, relevant actors from as many areas as possible (production, sales, use, disposal, science, experimental stations, extension, NGOs, etc.) should be involved in order to avoid partial solutions that cause new problems elsewhere. A conflict-sensitive exchange and solution-oriented cooperation across these different areas is important for finding better solutions for the functions and effects of agro-plastics. The basis for this would be conducive framework conditions for communication, cooperation and coordination and the development of a knowledge system for systematising and continuously reviewing the status quo and innovation and transformation goals. This would enable research and development, experimental stations and advisory services to address questions on effects and alternatives in a problem-oriented manner. As the topic lies between different policy areas such as sustainable food systems, biodiversity, climate protection, circular economy and regional development, inter-ministerial coordination in shaping the framework conditions that motivate actors in the search for more sustainable solutions is recommended. A technical and conflict-sensitive preparation of the topic for different target groups improves the knowledge base for the development of concrete short-, medium- and long-term solutions.

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