High-Yielding Grass-Clover Mixtures Achieve Numerous Aims

Grass-clover mixtures serve to produce high-quality forage and are mainly grown in arable-crop rotations. Their advantages over heavily fertilised pure-grass crops in terms of nitrogen efficiency are well known.
A recent study shows that they also perform better when many parameters are considered simultaneously.

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Using a new integrative approach, Agroscope experts investigated the multiple functions of grass-clover mixtures in terms of production, forage quality, weed suppression and sustainability in a three-year field experiment, and compared them with those of pure grass and clover crops. The four selected species differed in their ability to fix atmospheric nitrogen (N) and in their physiological development rate. In addition, all stands were managed at several nitrogen fertilisation levels. To determine multifunctionality, a new measure was developed that avoids the problems of previous methods (see box).

Advantages of the mixtures lead to high multifunctionality

Balanced mixtures with two grass and two clover species showed 61% greater yields than the pure crops, as well as lower yield fluctuations over time and thus higher yield stability. They also had 81% less weed biomass, 46% higher N-use efficiency and 96% higher nitrogen fixation, but almost no nitrate in the soil water. All of these positive effects were achieved along with a high forage quality. Calculated across all functions, multifunctionality of the mixtures was almost twice as high as that of the pure grass and clover crops. The advantage of mixing crops was so strong that a balanced mixture fertilised with 50 kg nitrogen per hectare and year had an equal or even higher degree of multifunctionality than a pure grass crop fertilised with 450 kg nitrogen per hectare and year. Moreover, high N-fertilisation rates generally reduced the advantages of the mixtures.

Conclusions

Conclusion: Grass-clover mixtures with complementary species can achieve high yields of high forage quality with high efficiency and low emissions.
In other words, they offer several advantages at the same time. This makes them ideally suited for productive, resource-efficient agriculture.

Grass-clover mixtures serve as a high-quality forage, and are mainly cultivated in arable-crop rotations.

No trade-offs between functions

The researchers were surprised to find no trade-offs between the functions. For example, they would have expected higher yields for the mixtures to be closely associated with a decrease in forage quality and yield stability, but this was not the case. Likewise, increased nitrogen fixation in the stands (with a high proportion of clover) and the consequently higher nitrogen availability might have led to more nitrate in the soil water. This was not found either, and nitrate concentration in the soil water of mixtures under standard fertilisation was negligible. This points to the high nutrient efficiency of grass-clover mixtures, coupled with a low negative impact on the environment. In addition, the comparison of multi-functionality of mixtures under low nitrogen fertilisation with that of highly-fertilised pure grass crops underscores the large savings potential of nitrogen fertilisers that can be achieved with grass-clover mixtures.

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Demonstrating multifunctionality of ecosystems

'Multifunctionality' refers to the ability of an ecosystem to perform several functions simultaneously, such as producing biomass, making nutrients available and storing carbon. Agroecological systems should provide other functions in addition to food production, such as maintaining soil fertility. Individual functions of grassland systems such as forage yield, forage quality or the reduction of nitrate leaching have been well studied. However, no study has yet investigated the multifunctionality of productive grasslands in an integrated approach that could also be tested statistically. Previous indices of multifunctionality were based on scaling the studied functions equally and calculating a mean value across all functions, which was then related to environmental factors (e.g. management intensity). However, the analysis of scaled mean values as a measure of multifunctionality makes it impossible to reveal relations between individual functions and environmental variables and to explain the underlying processes of multifunctionality. Moreover, it has been shown that such analyses sometimes led to erroneous conclusions.

In the present work, a new approach was developed that overcomes these problems. The data were first analysed with a multivariate model, which made it possible to capture the relationships between all functions and their dependence on environmental factors (here: plant diversity and N fertilisation). Based on this model, a measure of multifunctionality was defined (the mean log response ratio across all functions) that also takes into account the correlations between the functions in the statistical tests.