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Gain in nitrogen yield from grass-legume mixtures is robust over a wide range of legume proportions and environmental conditions

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Abstract

Global food security is currently challenged and requires sustainable intensification of agriculture through initiatives that include more efficient use of nitrogen (N) and increased protein self-sufficiency through home-grown crops. Such challenges were addressed in a continental-scale field experiment conducted over three years, in which the amount of total nitrogen yield (N_{tot}) and the gain in N yield in mixtures as compared to grass monocultures ($N_{gainmix}$) was quantified from four-species grass-legume stands with greatly varying legume proportions. Stands consisted of monocultures and mixtures of two N_2 fixing legumes and two non-fixing grasses.

The amount of N_{tot} of mixtures was significantly greater ($P \leq 0.05$) than that of grass monocultures at the majority of evaluated sites in all three years. N_{tot} and thus $N_{gainmix}$ increased with increasing legume proportion up to one third of legumes. With higher percentages of legumes, N_{tot} and $N_{gainmix}$ did not further increase. Thus, across sites and years, mixtures with one third proportion of legumes had 57% higher N_{tot} than grass monocultures and attained ~95% of the maximum N_{tot} acquired by any stand.

The relative N gain in mixture ($N_{gainmix}/N_{totmix}$) was most severely impaired by minimum site temperature ($R = 0.64$, $P = 0.010$). Nevertheless, $N_{gainmix}/N_{totmix}$ was not correlated to site productivity ($P = 0.500$), suggesting that, within climatic restrictions, balanced grass-legume mixtures can benefit from comparable relative gains in N yield across largely differing productivity levels.

We conclude that higher N output (N_{tot} or forage protein per unit area) can be achieved with grass-legume mixtures than with pure grass alone for a given amount of N fertilizer applied; conversely, the same N output can be achieved by mixed swards with less input of N. Therefore, the use of grass-legume mixtures can substantially contribute to resource-efficient agricultural grassland systems over a wide range of productivity levels, implying important savings in N fertilizers and greenhouse gas emissions.

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