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Integrating underutilised species and crop wild relatives with conservation agriculture for climate-resilient food systems

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Abstract

Biodiversity loss, narrowing genetic pools, land degradation, and nitrogen losses threaten the resilience and sustainability of global food systems. Integrating underutilised species and crop wild relatives (CWRs) within conservation agriculture (CA) systems offers a promising pathway for climate-resilient food production. In wheat-based systems, mixed cropping of multiple wheat genotypes and wild wheat relatives demonstrated superior performance under extreme arid conditions and high temperatures in Oman, stabilising yields while enhancing soil health. Lentil and chickpea intercropping with wheat further improved system productivity, resource-use efficiency, and water-use efficiency (WUE). Diversification of cropping sequences, including oat, barley, millets, cowpea, and sesame, contributed to improved system resilience, enhancing nitrogen-use efficiency (NUE), reducing greenhouse gas emissions, and increasing profitability. Sorghum, incorporated both as a rotational crop and as a mulching material, provided biological nitrification inhibition (BNI) benefits, improving soil nitrogen retention, reducing weed pressure, and enhancing NUE. The application of sorghum extract coatings on urea further optimised nitrogen availability, lowered losses, and minimised reliance on synthetic fertilisers. Zero-tillage and no-tillage practices within these diversified systems supported soil structure, moisture conservation, and long-term soil functionality. The use of wild wheat relatives as breeding sources facilitated the introduction of adaptive traits, enhancing tolerance to heat and aridity. Systems integrating multiple genotypes and species exhibited superior stability compared to monocultures, particularly under extreme climatic conditions. In conclusion, the combination of crop diversification, underutilised species, ecological nitrogen management, and CA practices resulted in stabilised yields, improved soil and water management, and reduced environmental impact. These findings highlight the potential of leveraging plant biodiversity and ecological interactions to design resilient, sustainable, and climate-smart food systems capable of maintaining productivity in arid and high-stress environments.

Keywords: Allelopathy, Biodiversity, Biological nitrification inhibition, Conservation agriculture, Intercropping, Soil health

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