

Alfalfa Intercropped with Corn & Sunflower Provides Profitable Ecosystem Services in Alfalfa's Establishment Year

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Alfalfa (*Medicago sativa* L.) is an important leguminous crop due to its high nutritive value as forage and its ability to biologically fix nitrogen in symbiosis with rhizobia in the soil. However, it faces the challenge of low yield and economic losses during the establishment year. Therefore, this study aims to intercrop alfalfa with corn (*Zea mays* L.) and sunflower (*Helianthus annuus* L.) in the northern Great Plains, Midwestern region of the USA, to increase alfalfa forage yield and nutritive value in the first production year, while providing profitable ecosystem services in alfalfa's establishment year. Additionally, the environmental impacts of alfalfa intercropped with sunflower and corn at two row spacings were compared with spring-seeded alfalfa grown alone in two-year systems. Corn-alfalfa intercropping was conducted at Prosper, ND, and Hickson, ND, between 2020 and 2024, while sunflower-alfalfa intercropping experiments were conducted near Prosper, ND, Hickson, ND, and near Red Lake Falls, MN, in 2021 and 2022. The Denitrification-Decomposition (DNDC) model was used to estimate changes in soil organic carbon and field emissions, including CO₂, CH₄, N₂O, NH₃, nitrate leaching, P runoff, and P leaching. Then, *SimaPro* Craft 10.3 (Recipe 2016 Hierarchical) method was used to calculate and compare the impact of each cropping system across the endpoint characterization factors relating to human health, ecotoxicity, and resource depletion. From the results, alfalfa intercropped with an annual crop in the first year was shown to be a profitable cropping system. Also, the integration of alfalfa into an annual cropping system showed a distinct reduction in emissions associated with ecotoxicity impact compared with annual monocropping. In terms of human health and resource depletion impacts, alfalfa showed a slight reduction in human health impacts and had comparable impacts to annual monocropping in resource depletion.

Acknowledgment: This research is funded by USDA-NIFA-SAS R-CAP Award #2021-68012-35917.