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Perspective

The Impact of Water-Saving Agriculture on Global Warming Potential in Semi-Arid Regions

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DESCRIPTION

Water scarcity and climate change are two major challenges for agriculture in semi-arid regions. Water-saving agriculture is a strategy to cope with water stress and improve Water Use Efficiency (WUE) by adopting practices such as deficit irrigation, conservation tillage, mulching, and crop diversification. However, water-saving agriculture may also have implications for the Global Warming Potential (GWP) of agricultural systems, which is the cumulative impact of Greenhouse Gas Emissions (GHG) on the climate over a 100-year period.

The GWP of agricultural systems depends on various factors such as soil type, climate, cropping system, irrigation method, and management practices. GHG emissions from agriculture include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), which have different warming effects and lifetimes in the atmosphere. CO_2 is mainly emitted from fossil fuel combustion, land use change, and soil respiration. CH_4 is mainly emitted from enteric fermentation, rice cultivation, manure management, and biomass burning. N_2O is mainly emitted from fertilizer application, manure management, and soil nitrification and de-nitrification.

Water-saving agriculture can mitigate GWP by reducing GHG emissions or enhancing carbon sequestration in soils and biomass. For example:

- Deficit irrigation is a technique that applies less water than the crop evapotranspiration demand, creating mild water stress that can stimulate root growth and WUE. Deficit irrigation can reduce GHG emissions by saving energy for pumping water, reducing soil moisture that favors anaerobic decomposition and CH_4 production, and lowering N_2O emissions by limiting nitrification and de-nitrification processes.
- Conservation tillage is a practice that minimizes soil disturbance and maintains crop residues on the soil surface. Conservation tillage can reduce GHG emissions by saving fuel for tillage operations, increasing Soil Organic Carbon (SOC) stocks that sequester CO_2 from the atmosphere, and decreasing soil erosion that causes CO_2 loss.
- Mulching is a practice that covers the soil surface with organic or inorganic materials such as crop residues, straw, plastic, or stones. Mulching can reduce GHG emissions by conserving soil moisture and reducing evaporation, enhancing SOC sequestration and soil quality, and suppressing weed growth and herbicide use.
- Crop diversification is a practice that involves growing different crops in rotation or intercropping. Crop diversification can reduce GHG emissions by improving nutrient cycling and soil fertility, reducing fertilizer and pesticide use, increasing biomass production and carbon sequestration, and enhancing pest and disease resistance.

However, water-saving agriculture may also have trade-offs or uncertainties for GWP depending on the local conditions and system interactions-Deficit irrigation may increase GWP by reducing crop yield and biomass production, which can lower carbon sequestration potential and increase CO_2 emissions per unit of output. Deficit irrigation may also affect crop quality and nutritional value, which can have implications for human health and food security.

Conservation tillage may increase GWP by creating anaerobic soil conditions that favor CH_4 production, especially in rice cultivation. Conservation tillage may also affect soil temperature and microbial activity, which can influence CO_2 and N_2O emissions. Mulching may increase GWP by increasing N_2O emissions due to higher soil temperature and nitrogen availability under organic mulches. Mulching may also affect soil pH and salinity, which can influence soil biogeochemical processes and GHG emissions. Crop diversification may increase GWP by increasing N_2O emissions due to higher nitrogen input and turnover under legume crops. Crop diversification may also affect crop-water interactions and irrigation requirements, which can influence GHG emissions from water use.

Therefore, it is important to evaluate the net effect of water-saving agriculture on GWP under different scenarios and

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contexts. This requires a holistic approach that considers the whole system dynamics and interactions among various components such as soil, water, climate, crops, management practices, and socio-economic factors. It also requires a multi-criteria assessment that balances the trade-offs and synergies among different objectives such as water saving, GHG mitigation, crop production, food security, income generation, and environmental protection.