EGU21-8780
https://doi.org/10.5194/egusphere-egu21-8780
EGU General Assembly 2021

Reducing leaching using the threshold nitrate root-uptake phenomena

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Reducing nitrate leaching from agricultural land to aquifers is a high priority concern for more than a half a century. Theory and observations of a threshold concentration of nitrate in the root-zone (Cmax), from which the leachate concentration increases at higher rates with increasing root-zone nitrate concentration, are presented. Cmax is derived both by direct results from container experiments with varying nitrogen (N) fertigation, and as calibration parameter in N-transport models beneath commercial agricultural plots. For five different crops, Cmax ranged between 20-45 mg/l of NO_3-N derived from experiments and models. However, for lettuce, which was irrigated with a large leaching fraction, a Cmax could not be defined. For the crops irrigated and fertilized in the warm/dry season (corn and citrus) experiments show a dramatic change in leachate concentrations and simulations reveal a wide range of sensitivity of leachate NO_3-N concentration to Cmax. Annual crops that are irrigated and fertilized in the cool/wet season (e.g. potato in Mediterranean climate) showed a distinct Cmax yet less dramatic than the summer-irrigated crops in the container experiment, and smaller impact of Cmax in models. Simulations showed that for summer-irrigated crops maintaining fertigation at C<Cmax has a significant effect on deep leachate concentrations, whereas for the winter annual crops the simulations revealed no threshold. It is suggested that for summer-irrigated crops fertigation below Cmax robustly serves the co-sustainability of intensive agriculture and aquifer water quality, for the winter crops it is suggested but benefits are not robust. For short season, small root-system crops (lettuce) efforts should be made to detach the crop from the soil.