Nutrient leaching and water recycling potential for vegetable production in Western Australia's sandy soils

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Abstract: Due to the inherently low water holding capacity of the sandy soils along the Swan Coastal Plain in Western Australia, horticulture producers irrigate frequently to maintain adequate soil moisture levels for crop growth. As a result, water and fertilizer use efficiency are reduced due to deep drainage and nutrient leaching beyond the rootzone. This scenario raises the potential for water and nutrients recapture via drainage water collection and recycling within farms. Hydrus-1D was used to simulate water and nitrate movement in a sandy soil profile during the cultivation of lettuce in summer and winter conditions, with results showing nitrate fertilizer losses up to 87%.

Keywords: *Nutrient leaching, Irrigation water recycling, Hydrus-1D modelling, Horticulture*

1. INTRODUCTION

Vegetables are primarily produced on sandy soils in Western Australia. These soils typically contain between two to four percent clay and less than 1% organic carbon. The retention of water and nutrients are, therefore, inherently low. Mobile nutrients, such as nitrate, can easily leach in these soils. Cations such as potassium, can also leach, with phosphorus leaching also occurring, mostly pronounced in the white sands given to its lower phosphorus retention index than the yellow sands. Past field trials used lysimeters to quantify water drainage and leaching of nitrogen fertilizer from cultivated areas with vegetables receiving irrigation and fertigation via overhead sprinklers (Lantzke et al, unpublished), observing that up to nearly 80% of the water and 50% of the nitrate applied was leached beyond the rootzone and not utilized by plants in yield production for optimal irrigation fractions for sandy soils (120-140% ETo). Given the reality of water and fertilizer leaching in vegetable farms in sandy soils in Western Australia, DPIRD is conducting the project "Evaluating on Farm Water and Nutrient Recapture in Western Australia Production Systems", which aims to install drainage water collecting systems under irrigated vegetable farms to collect and recycle water and nutrients within farms for improved water and fertilizer efficiency and to minimize negative impacts on waterways and environmentally sensitive areas. To further assess water drainage and fertilizer leaching and their recapture potential in horticultural systems, HYDRUS-1D was used to simulate the leaching of water and nitrate in a sandy soil cultivated with lettuce for summer and winter conditions.

2. METHODOLOGY AND RESULTS

The software Hydrus-1D was used to simulate the distribution of water and nitrate ion in a sandy soil profile of 100 cm depth, considering the distinct characteristics between the 0-30 cm (grey sand) and 30-100 cm (yellow sand) layers. The simulation was conducted for two scenarios: a summer lettuce crop cultivated for a total of 42 days, and a winter crop for a total of 84 days. The nitrogen requirements were calculated based on the 3-Phase Fertilizer application program, with the model crops receiving a total of 216 and 450 kg/N/ha for the summer and winter cropping season, respectively. Nitrogen fertilizer application rates (kg/ha) were converted to equivalent to nitrate concentration (mmolc/cm^3) for the model input and nitrate considered as the only nitrogen source. Daily irrigation requirements considered in the simulation were calculated based on the available weather data record, where the daily requirements were calculated as the difference between the calculated crop evapotranspiration (ETc) and the occurring precipitation. As the main modelling process, a solute transport with nonlinear cation adsorption was used, where water flow, standard solute transport and root water uptake for lettuce, selected from the Hydrus-1D database, were used. For the soil solute transport parameters, the dispersity (Disp) and partition coefficient (Kd) values, were obtained using the STANMOD software (Šimůnek, 1999). The soil moisture distribution in the soil profile throughout the growth cycles were obtained (Figure 1). The initial soil moisture content was set at 14% WVC (2.5 kPa) prior to transplanting. The nitrate concentration distribution in the soil profile was simulated, from which the nitrate losses, by means of concentration reduction, between fertilizer applications were calculated for the 10 cm depth layer as an indication of nitrate leaching (Figure 2).

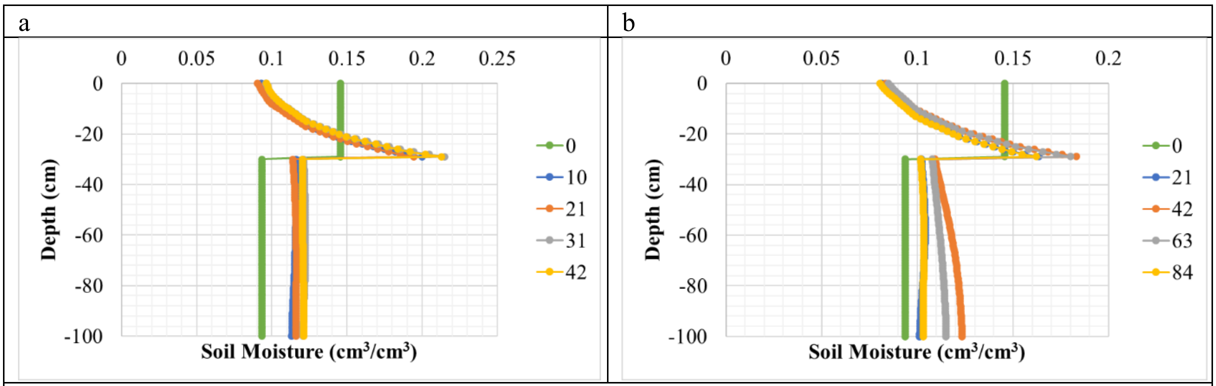

Figure 1 - Hydrus Simulation of Soil moisture profile during a (a) summer (42 days) and (b) winter (84 days) lettuce crop receiving daily irrigation when rainfall was less than measured evapotranspiration. Each coloured curve represents days after transplanting.

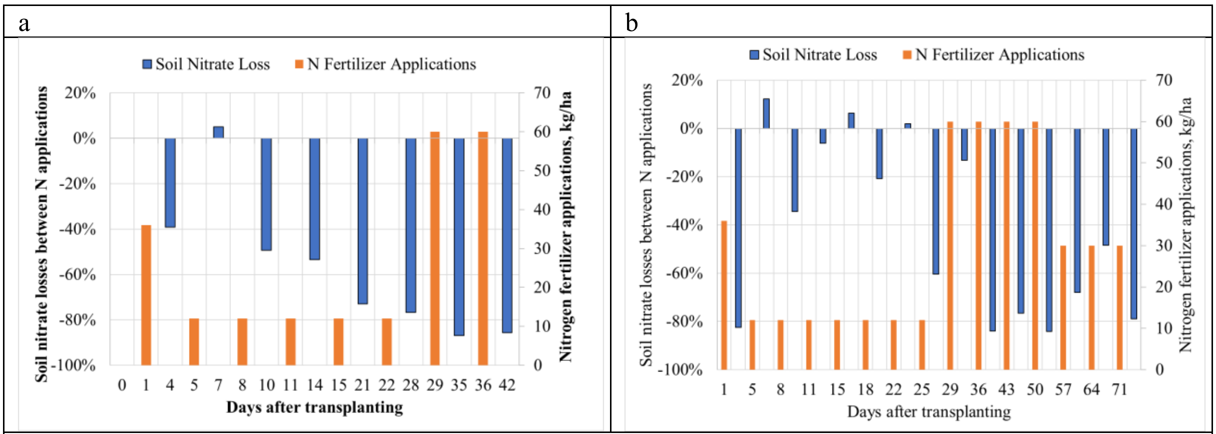

Figure 2 – Distribution of nitrogen fertilizer application rates and the percentage of soil nitrate loss, at 10 cm depth, between applications for summer (a) and winter (b) cropping seasons.

3. CONCLUSIONS

The simulation revealed a similar soil moisture distribution behaviour along the cropping period for both summer and winter conditions. Contrary to expected, moisture progressively increased with depth up to 30 cm depth, where there is a transition in soil layers, beyond which, the soil moisture distribution is uniform throughout the soil profile, showing deep drainage, probably from a 44% higher saturated hydraulic conductivity for the yellow sand than the top grey sand layer. The concentration of nitrate in the 10 cm soil layer was observed to reduce up to 87% between fertilizations in summer and winter. The concentration reduction tends to be less pronounced during the establishment phase (14 d in summer and 29 d in winter) when fertilizer application occurs every 3 days, becoming more pronounced as applications are spaced weekly. The modelling of water and nitrate movement in soil profile depth shows a great potential for drainage water and fertilizer capture and recycling for horticulture farms operating in sandy soils. Future work will investigate improving the model and validating results in the field.

ACKNOWLEDGEMENTS

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