Fertilizer-drawn forward osmosis for irrigation of tomatoes

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ABSTRACT

Fertilizer-drawn forward osmosis is a low-energy desalination concept particularly developed for the irrigation use of desalinated water. It has an advantage of not requiring regeneration of the draw solution (DS), thus, it can be used directly for the purpose of irrigation without any additional treatment. The current study was aimed to evaluate the real application of forward osmosis (FO) targeting irrigation of tomato crops based on their fertilizer requirements. Fertilizer-DSs were prepared to drive seawater desalination using commercially available fertilizers such as NH4NO3, NH4Cl, KNO3, KCl, NH4H2PO4, and urea. DSs were prepared to represent varying nitrogen:phosphorous:potassium (N:P:K) ratios used in assorted tomato growth stages. The FO performance evaluated in terms of the flux and reverse solute flux (RSF) showed significant variations in outcome. The resultant flux for different DSs was influenced by the particular fertilizer present in DS mixture and its concentration. This flux varied from 2.50 to 12.49 LMH. Comparatively, DS carrying high osmotic pressure components showed high-flux outcome. The fraction $j_w/\Delta \pi$ of these fertilizer-DSs varied from 0.062 to 0.19 LMH/bar, which indicates a changing flux outcome against the same osmotic pressure. To select the best performing fertilizer-DS, nitrogen source fertilizers like urea, NH4NO3, and NH4Cl were further evaluated for 10-0-10 NPK value. It was found that NH4Cl-based DS mixtures performed better than urea- and NH4NO3-based DS. The RSF results indicated that all nitrogen- and potassium-based DS exhibited higher N- and K-RSF. However, the DS using NH4H2PO4 delivered extremely low P-RSF of 12.35 g/m²/h. Long-term run tests with seawater quality feed solution resulted in FO producing a final DS enriched in nutrients greater than the tomato plant’s requirement. This implies that the use of dilution or any other technique to reduce excessive nutrients is essential before using the final DS for tomato irrigation.

Keywords: Forward osmosis desalination; Fertigation of tomato; NPK crop nutrients; Fertilizer-draw solution; Seawater feed