J Food Process Technol 2017, 8:1(Suppl)
http://dx.doi.org/10.4172/2157-7110.C1.060

Evaluation of optimal irrigation scheduling to manage salinity and water use for field crops grown in a case study farm in Vaalharts irrigation scheme of South Africa: Application of evolutionary algorithms for intra-seasonal optimization under production uncertainty

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Statement of the Problem: In Vaalharts irrigation scheme of South Africa, farmers need solid information on how to develop sound irrigation strategies for field crops grown on shallow water table soils in light of declining water quality and rising electricity tariffs to maximize profits while minimizing the impact of salt return flows on the environment.

Aim: The main objective of this research is to develop a bio-economic salinity management model to evaluate the stochastic efficiency, water use efficiency and environmental impact of optimal irrigation scheduling practices while cognizance of irrigation water quality, soil conditions, irrigation technology constraints, crops and stochastic weather.

Methodology & Data: The intra-seasonal Soil Water Management Program Economic model (SWAMP-ECON), which is a simulation-optimization model, was developed to deal with the main objective of the research. The simulation part comprises the Soil Water Management Program (SWAMP) crop growth model which was supplemented with economic module to quantify the economic impacts of alternative irrigation schedule options while the optimization section uses special evolutionary algorithms (EA) to find optimized irrigation scheduling for a field crop. State-contingent approach was followed to model production uncertainty in SWAMP-ECON.

Findings: Compared to current farmer's irrigation strategy of a field crop, the optimized irrigation scheduling strategy derived for a risk neutral farmer significantly improves the stochastic efficiency, water use efficiency and environmental impact when growing a field crop by using deteriorating water quality. On the other hand, compared to risk neutral farmer, a risk adverse farmer will choose an optimized irrigation scheduling with more water to reduce the variability of net return from the crop.

Conclusion & Significance: The model provides better insight on how to derive sound irrigation scheduling under saline irrigation water on constant shallow water table soils. The model to be of practical use, it should be extended for cropping systems and for soils with fluctuating water table conditions.

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