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Hydraulic and agronomic constraints of on demand pressurized irrigation networks optimization

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The pipe-size optimization of water distribution systems has attracted many researchers who, very often, formulated an objective function leading to minimize their capital and/or operating cost. However, the optimal design of distribution systems is a process involving not only the cost but also the performance. To a greater extent, accounting for the performance in the optimization process is important when dealing with on demand schedule. Actually, the temporal and spatial variability of the hydrants operating simultaneously leads to a variability of flow regimes in on demand pressurized irrigation systems, inducing uncertainty in pressure head at the hydrants and thus, affecting the system hydraulic performance. Moreover, the on-farm networks operating downstream are designed for a fixed upstream pressure head that usually corresponds to their best achievable performance.
Based on these considerations, an on demand irrigation system was optimized according to Clément, FAO and Reliability based models using Labye iterative discontinuous optimization algorithm. For the three optimal networks, the variability of flow regimes, system cost and hydraulic reliability were assessed with AKLA model. By generating peak configurations of hydrants in simultaneous operation, the interaction between the head variability at hydrant and the uniformity of the downstream operating on farm sprinkler systems was analyzed in each optimized network. In a first step, the relative pressure deficit and consequently the pressure at hydrant level was calculated for each generated configuration. In a second step, an iterative model was applied to generate the characteristic curve of each on-farm sprinkler network, and by intersecting the on farm curve with the hydrant characteristic curve, the actual operating discharge and pressure of the on farm sprinkler network was defined and consequently, uniformity coefficient at farm level at 90% probability of occurrence was calculated. In a last step, and considering a typical farm representing the study area cropping pattern downstream each hydrant, the multiplicative form of crop water production function accounting for the deficit coefficient was used to calculate the relative yield. The results show that the Reliability based optimal network has registered a significant reduction of cost of respectively 15 and 24%, and of reliability of respectively 10 and 13%, as compared to Clément and FAO. However, the relative pressure deficit at hydrant demonstrated the non significance of reliability reduction as the registered corresponding head failure was minimal. As a matter of fact, the relative yield at system level was reduced by only 1% as compared to Clément and FAO.
This study clearly shows that accounting for the performance and the interaction between the distribution system and the on farm irrigation network is a must in the modernization/rehabilitation processes, often promoted as tools to produce more agriculture goods with less water input at moderate investments and operational costs.