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Potentials and Development of Precision Irrigation Technology

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CONCLUSIONS AND RECOMMENDATIONS

The potential to reduce yield variability an one field, optimize Input-Output relations and save resources like water and energy, appears to be realizable by changing management strategies in the direction of precision farming. Environmental legislation regarding the optimal benefit of Inputs, and market pressures for traceability and audit trails in the new decade will force producers to seriously consider precision farming as a solution. Precision irrigation provides the opportunity to decrease Input costs and potentially increase net income by applying water at the right place with the right quantity at the right time. Fields that show spatial variability in AWC would benefit from a precision Irrigation system which has the ability to vary the amount of water applied. An important future aspect of precision Irrigation is to establish delineation strategies for *in--field* spatial variability, analysis techniques and decision aids that can be used by producers. This study focused an an approach for establishing a strategy for precision irrigation; through examining the suitability of EM38 for AWC delineation in the field, changes in irrigation depth in travel direction with mobile-reel irrigation system and the development and implementation of a demonstration unit of an automated, spatially variable center pivot irrigation System.

Because the extent of the soil's EC is primarily but not only, attributable to the amount of any free moisture in the soil, the established strategy assumed ECa measured using EM techniques could be used as indicator or surrogated property to quantify *in--field* spatial variability in order to develop more precise variable- rate water application maps. Though this study did not rely an ECa measurement *per se,* results shown in Section 5.1 demonstrate how ECa related to AWC, a soil property that could be of interesting precision irrigation. More work will be needed in areas with a wide range of ECa differences, such as Jordan, to verify these results and establish a Standard related ECa with AWC. In any case, if the uncertainty in results appears to be too high, either sampling density has to be increased or an attempt has to be made to back-calculate soil properties from yield maps. As proposed in the strategy, the variable-rate water application could be fulfilled by using some available technologies, such as speed control Systems and regulating discharge rate.

As results in Sections 5.2 and 5.3 indicated, Speed control systems succeed in adjusting travelling speeds of mobile-reel machines at acceptable accuracy which, in turn, change the amount of applied water exponentially. Results presented in Section 5.4 justified the modifications established to the commercial center pivot irrigation system using solenoid valves and controlled with PLC to produce variable-rate water application System to irregular-shaped areas. The PLC obtains the positional information and open/close the addressed solenoid valves to obtain the target depth. The concept of pulse irrigation is technically feasible and a viable method of reducing application of water below that determined by the Speed of the parent center pivot System. Further studies an this concept should be conducted to determine its potential and extend its use beyond the research phase to commercial Irrigation machines for which spatially varied water application is desired. Results showed that the PLC was successful in varying the amount of water throughout the field with some deficiencies at the borders due to large throw radius of the nozzle. Also, it was concluded that the PLC was not adequate in its current configuration for the experiments which were to be performed, including fertilization and chemical treatments. Precision irrigation gives farmers the ability to more effectively use water and other crop Inputs including fertilizers and pesticides, which will improve crop yield and/or quality, without polluting the environment. However, it has proven difficult to determine the cost benefits of precision Irrigation, since, at present, many of the technologies used are in their infancy, and pricing of equipment and Services are hard to pin down. This can make any current economic Statements about a particular technology dated. But, as a general Statement, the economical and environmental benefits of taking into account within-field spatial variability appear obvious, although they have yet to be generally proved in field trials and experiments. Considerable research and development are needed to realize the potential benefits of site-specific irrigation and to ensure a net economic return to the producers. Also, it is necessary to recall that the added benefits from variable rate application should be weighed against the additional investment and Operation costs involved. Evaluation of these expenses is beyond the scope of this paper, and is another important direction into which this research can be profitably extended (Feinermann and Voet 2000). The environmental benefits of decreased chemical inputs are an important part of management that is minimally factored into many farmer decisions and is likely to be increasingly important in the future. This work, that has been mostly qualitative, should be continued with complementary research of more precise quantitative approaches concerning the environmental and economic benefits. As a recommendation, precision farming or site-specific management as the process of managing variability which, in turn, has a potential to contribute towards improving the Overall efficiency of the agronomic process (Earl et al., 1 996). This improved efficiency is beneficial to the farm, both economically and environmentally. The use of precision farming for irrigation water management, precision Irrigation, is still in the development stages and requires experimental works to determine its feasibility and applicability. This study has focused an approach for establishing a strategy for precision Irrigation. From the reviewed literature and presented results, the following Could be recommended for future works:

- The key lesson is the need to develop decision Support tools to support producers with additional information to analyze the Situation and change their own management strategies (Heermann et al., 2000).

- ECa measured with EM38 may be used in the future for developing water application maps. But, development in sensing technology may be required, through which direct Information Could be collected while the machine moves (feedback) and be integrated to the control System to change the amount of irrigated water.

- The aim of varying the application of water throughout a field suggests, water-soluble fertilizers and chemicals can also be variably applied. Therefore, a continuing part of the site specific irrigation control system must be the application of fertilizers and chemicals using the precision Irrigation control System.

- The control programs need to have automatic records an the amount of water applied through the season, the times at which he systems are irrigating, travelling without irrigating, and maintenance down times as well as storage of treatment area databases.

Site-specific management is the application of Information technology to crop production (Plant, 2001). Information, like any other production factor, has both a value and a cost. More generally, in Order for the value of site- specific Information to exceed the costs of acquiring it, knowledge must exist of how to use that information to appropriately adjust management practices, and this knowledge is still not available at a sufficiently precise level.

Some preliminary experience is available that permits speculation an its benefits. But, considerable research and development is needed to realize the potential benefits of site specific Irrigation and ensure a net economic return to the producers, in Order to give farmers confidence that the use of these technologies is practical and potentially valuable in improving production.

Methodology for predicting the potential environmental and economical benefits for a particular site is needed to facilitate the adoption and implementation of this technology where appropriate. The area that is likely to need continuing development for the foreseeable future is the software to support the farmer while making decisions concerning appropriate treatments and levels of treatment to be spatially applied (Blackmore et al., 1 994). Also, Software development should be continued to make it easier for the irrigator to convert real-time sensed data into Sprinkler control commands for automated implementation of spatially variable water, fertilizers and chemicals application (Duke et al., 1997). Another aspect in this direction is the ability to create/read a treatment map that is stored an a smart card (credit-sized memory card) or Computer disc that is inserted into the controller in the equipment concerned.