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Variable Rate Irrigation for Precision Water management

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Abstract: Agricultural sector takes the responsibility of serving an increasing population with freshwater sources that are reduced or depleting. Innovations in irrigation technologies and services enables site-specific use of in-field irrigation water to enhance the accuracy of water use or minimize water use for sustainable agriculture, particularly in arid and semi-arid locations. Recent developments in variable-rate irrigation (VRI) technology, knowledge and information for the implementation of VRI, and the influences of VRI, such as the profitability of the use of this technique, are addressed in this paper, focusing on agricultural variables in the precise water resource management. The invention of sprinklers has made it possible to apply irrigation towards better accuracy at the independent spray control scale. In order to assess VRI prescription map combining various soil and plant features of various ecosystems, more study is needed. System provides required information for realistic VRI implementations, on-farm tests and whole-field investigations are necessary. Modification of the spatial distribution of prescription areas in reference to temporal variability in soil water condition and crop farming practices, that can be assessed by integrating remote and proximal sensing data, also needs to be addressed in future studies. Comprehensive decision-making support techniques are needed to aid the consumer determine where and how to allocate the amount of irrigation water at specific stages of crop growth to maximise the use of water and crop production based on individual weather patterns and crop management.

Keywords: Agricultural Practices, Irrigation, Crop Production, Variable-Rate Irrigation (VRI) Technology

INTRODUCTION

As plant growth primarily depends on the availability of water, agriculture is the largest user of the world's available fresh water. The world currently irrigated area is approximately 300 million hectares, as per the Food and Agriculture Organization (FAO), and the forecast for 2050 indicates an increasing lack of water supplies for farming, while water is a renewable energy source. The strength of world food shortages, climate change, and poverty have exacerbated this condition. In the face of the depletion of freshwater resources, the biggest problem for agriculture is supplying food and fibre to almost 8 billion people worldwide[1].

In arid and semi-arid areas, where groundwater supplies, in particular aquifers, have been used for irrigation, the problem is more prevalent, as rainfall provides only a fraction of the overall requirement for crop evapotranspiration (ET). Intensive irrigation of several aquifers has created significant depletion. For example, contrasting the water level of the Ogallala aquifer in the 1950s to that of 2013, up to 78 m of water in the Texas High Plains region was drained in some wells. It's almost twelve times the 4.5 m average decrease for the entire aquifer region.Experts estimate that 35 percent of the Southern High Plains would not be capable of sustaining irrigation in 30 years, considering this decline speed. In recent years, several other water supplies in the globe have been rapidly diminishing with a minimal regeneration, suggesting the need for approaches to conserving water in farming. To improve conserve water and enhance the productivity of water use for sustainable agriculture, more efficient and appropriate water management is needed.

Without integrating the inherent variability in topography, soil, crop growth conditions, and other agronomic variables, traditional farming practises control an agricultural area systematically. This can lead to nutrient leakage, pollution of the soil, and lower profits, particularly when high supplies are applied in low-yielding areas, and vice versa. To split the land into tiny management programs for optimised production, precision agriculture can be adopted. There are many concepts for precision farming, and with new technology and awareness of what is possible, it continues to growIn the early 1980s, the principle of precision agriculture or site-specific management began with the introduction of different technologies to evaluate field variables like soil survey, soil sampling and mapping, and agricultural productivity tracking. Precision farming relies on comprehensive spatial data, information systems, enhanced capacity to process data, and good decision aids. Precision agriculture is a control device that detects and reacts at the sub-field level to the spatial and temporal distribution of soil and crop production with the goal of raising profitability and reducing the environmental impact.

Geographic information systems (GIS), remote and proximal sensing, Global Navigation Satellite System (GNSS), production tracking and variable rate technology are major technologies employed in precision agriculture. Utilizing GIS, proximal detectors and monitoring devices, geo-referenced data on soil and crop properties can be collected effectively. The implementation of yields detectors offers the opportunity to reliably characterise yield variability in the field at large scales. In addition, the variable rate technology offers the option to apply irrigation water directly to the site in order to accomplish future water saving.This makes it possible to apply water in a timely and precise manner, integrating temporal and spatial properties of soil and plant demand at various stages of growth. In other words, the technique of variable rate irrigation (VRI) will help to deliver the required amount of water at the right time and at right region of the farm, leading to water saving[2].

For the successful introduction of the various developments, a deeper understanding of farm variation and how it affects crop yield is required. A study of site-specific irrigation for sprinklers based on the technologies and deployment issues. The value of understanding the crop response to VRI was addressed in an another study of 20 years of research on raising crop productivity with sprinklers and micro-irrigation. The study emphasized the need for constant efforts to delineate the control zone collected from field property combined with complex real-time monitoring information on climatological and crop information.This research, however, concentrated more on the technical side of irrigation management than the agricultural dimension of VRI water conservation. Equally important to the successful application of these technologies is the agricultural science supporting VRI. The goal of this paper is therefore to review the scientific history and technologies in precise water management, with an emphasis on agronomic variables and site-specific water management techniques.

DISCUSSIONS

Variable-Rate Irrigation Technologies

From gravity-based furrow irrigation in the 1950s to sprinkler irrigation in the late 1990s, the irrigation method has modified. In the 1980s, the high-pressure sprinkler irrigation system became available exclusively, which was further transformed in the 1990s into low-pressure sprinkler systems and low-energy precision application (LEPA). In the U. S., around 49 percent of total irrigated area is irrigated with centre pivot technologies, of which 44 percent is irrigated below 30 psi at low pressure. Sensors and spatial details, prescription maps and a device to implement VRI prescription (e.g., LEPA, lateral irrigation, etc.) to be used in the field are the minimum standards for the VRI technologies.There are currently multiple sustainable agriculture irrigation techniques, like sprinkler, drip, as well as other micro-irrigation technologies, but few site-specific investigations have been carried. A analysis of the variable-rate drip irrigation on vineyards, for instance, showed that production was increased by up to 17 percent and water usage decreased by 20 percent in comparison to standardized irrigation. In the United Kingdom, researchers measured the capacity of hose-reel booming irrigators for precise vegetable irrigation. In Europe, automatic gravity-fed irrigation systems minimized manual labour and encouraged creative farmers' acceptance.

In contrast to uniform flooding irrigation, variable-rate irrigation that use the centre pivot in rice gave good results. In this analysis, we will concentrate more on those irrigation methods, like variable-rate lateral irrigation systems and centre pivot irrigation systems, which has been used more commonly across the globe for site-specific water management.The elements of a lateral variable-rate irrigation system typically comprise of a GPS or GNSS receiver, custom software-controlled repeaters and injectors that will use the nozzle-pulsing method and a variable speed control system to implement varying water. With high precision, this device can monitor the irrigation frequency and forward velocity. Likewise, a pivot control panel, a VRI control panel, solenoid valves, control nodes, a GNSS system, a variable frequency drive, and a remote control system are elements of a centre pivot VRI device.The pivot control regulates the pivot's activity and velocity, while in reaction to the prescription mapping and the pivot position, the VRI control center controls the irrigation water pace. The movement of sprinkler system is controlled by solenoid valves.

A pivot position is given by the GNSS method at the edge of the centre pivot. Whenever the valves are open or close, the control node along the width of the pivot decide. The variable frequency drive (VFD) helps control the pressure while adjusting the irrigation frequency at different field locations instantly.By seeking feedback from a pressure switch mounted on the pump outlet pipe, the VFD regulates the rotation speed of the pump impeller. Under predetermined higher and lower limits, this maintains water pressure constant and thus saves water and energy. The remote control device allows the centre pivot and the pump to be viewed and operated from a distance from a mobile or a desktop using Network. In addition, scientific research are striving to monitor the amount of irrigation with VRI controllers using real-time plant and soil sensor data in the region[3][4].

Several firms are currently working on the development and implementation of this technology. The VRI control resolution that is commercially available differs between producers. By opening or closing specific nozzles and adjusting the speed of the pivot, VRI devices may administer zero water to specific nozzles and as much as 200 percent of the normal application rate to other nozzles. A few businesses have the opportunity to monitor sprinkler areas, whereas others separately monitor each sprinkler. For instance, Valley (Valley, Valmont Irrigation, Valley, NE, USA) provides technologies for variable speed operation and variable zone regulation for the application of site-specific water.An innovative control panel is used by the variable controller system to reduce speed or increase speed the pivot to adjust the water input in different areas (sectors) of the field, but the overall flow rate of the pivot remains constant. The current pivot irrigation process does not involve extra equipment for this system. The variable zone control system will adjust the center's speed as well as adjust the frequency of deployment along the lateral pivot.

By turning sprinklers on and off for varying periods of time, this method applies different irrigation depths to various areas of the field. The Irrigate-IQ Variable-Rate Irrigation System was built by Trimble (Trimble Navigation, Sunnyvale, CA, United States).However, several variables, such as field characteristics, the spatial resolution of sensor used in irrigation management and the temporal resolution of data inputs, as well as unpredictable environmental conditions, affect the output of these irrigation systems in field applications. To enhance the adoption and application of VRI, adaptive irrigation management techniques and ongoing research assistance are therefore needed[5][6].

Precision Water Management Strategy

To enhance agricultural production within water-limited circumstances, numerous precision irrigation methodologies have been applied. However, for improved productivity and effectiveness for site-specific techniques, suitable precision irrigation approaches are equally essential. For site-specific maintenance, the creation and implementation of management zones utilizing spatial and temporal information on numerous agricultural variables has been practised over many years. The use of artificial intelligence in prescription map production for site-specific water management has also been the in recent decades.

1. Managing Zone
2. Advancement of Site-Specific Water Management Strategy
3. AI and Extensive Studies

CONCLUSION

In order to allow site-specific control of irrigation water for optimised agricultural production, data collection and management technologies like production monitoring, detectors and sensing systems, GIS, GNSS, and decision analysis techniques are available nowadays. Significant improvement of irrigation control systems gives the person several choices for VRI implementation. Many researchers have analysed and established irrigation techniques, strategies for prescribing, and management of profits included in VRI. In the development and integration of this application, however, there are some difficulties.

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