Advances in Using Center Pivots for Site Specific Management

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Summary: Historically center pivot irrigation has treated the entire field the same. Changes in technology have occurred which allow growers some limited ability to apply differing amounts of water and nitrogen fertilizer to different sectors of the field. This paper will discuss the currently commercially available options, their costs and their potential impact to growers. Also a brief discussion of the adoption of these options will be presented. Additionally the paper will present information on prototype site specific equipment and issues surrounding the broad adoption by growers and the needs for research seen before commercial products will be viable.

Introduction: Since the introduction of the center pivot in the mid 1950's, the mechanical move industry has continued to improve and develop products to better meet the needs of production agriculture. These improvements would be focused in four primary areas - drive train, structure, water application and controls. Overall goals were to provide uniform irrigation of the field with a specific application depth and at the same time in a cost effective fashion.

This has led to the development of changes in the water application devices and controls with the more recent focus on reductions in labor, water use and energy. Sector control has generally been limited to the endgun(s) on the center pivot. Some manufacturers offered specific special application sprinkler packages such as the Slurry Shooter™, Seedigator™ and Slurry Manager™ for special applications and to sequence sections of pivots on and off. Center pivot manufacturers developed sequencing packages (sector control of parts of the center pivot) with the introduction of corner arm options for center pivots to ensure as the corner arm extended and retracted water uniformity remained good. In the early to mid 1990's with the commercial introduction of automated controls for center pivots by the manufacturers it became easier to program a change of the ground speed of the center pivot for a specific area of the field. This speed change would result in a change to the applied depth of irrigation in a specific pie shaped area since the change in the water depth applied is directly proportional to the change of ground speed. However, in general the overall goal of the center pivot remained the same – to maintain uniformity of the application depth both along the center pivot and in the direction of travel.

Some cases did exist where farmers wanted to turn off the flow of irrigation to specific sections of the pivot due to a well head, wetland area or other reasons. The automated center pivot control panels made this easier as many had one or two auxiliary controls that could be programmed to turn a valve (or group of valves) on and off plus one or two endgun functions. Irrigation dealers and farmers took the lead creating some functional packages. A very small percent of center pivots have ever been operated in this fashion. Still overall the farmer treated the entire field the same – utilizing the same amount of seed, fertilizer, and other crop production inputs.

With the introduction of precision agriculture suddenly much more information was available for a particular field from yield, soil and fertility maps. Farmers now had data indicating the variability across the field that probably was already suspected. The challenge became how to use this data and how to make changes impacting different areas of the field. Fertilizer and chemical application equipment as well as planters have been equipped to make changes in rates or volumes across the field. As long as water for irrigation was plentiful and energy costs reasonably low the easiest management scheme for irrigating farmers was to put on 'a little extra' or not worry about an area receiving more than warranted by the yield.

This has all changed with droughts in the United States and other limits on the availability of water coupled with the recent rapid rise in energy and other crop production input costs. A number of questions begin to be asked:

- Can a farmer still irrigate the same way they always have and remain profitable?
- How much can a farmer justify spending on improvements to manage resources on a smaller scale than the entire field.

Objective: The goal of this project is to review the status of current research and commercial variable rate options, their costs and their potential impact to growers. Then the constraints to acceptance in the marketplace will be reviewed.

Discussion: Research into variable rate or site specific irrigation has been conducted at a number of locations across the United States by both Universities and USDA-ARS. These include but are not limited to Universities of Georgia, Idaho, Nebraska and Texas A&M and the USDA-ARS at Florence, SC and Ft Collins, CO. The first commercial marketed package has been jointly developed by the University of Georgia, FarmScan and Hobbs and Holder. These units have primarily been installed in the southeastern United States.

Valmont Industries has been evaluating the market opportunities and a concept unit for variable rate or site specific irrigation. The following is some of the initial analysis of the issues seen to adoption of site specific irrigation. Using some preliminary data Valmont has made the following estimates of costs and benefits. These are broken into two different broad examples – water / energy savings and nitrogen savings.

- Example #1
    - Assumptions
        - ¼ mile (395m) center pivot
        - 150ft (46m) pumping level
        - 800gpm (51lps)
        - 25psi at the pivot (17.6m)
        - 18in (457mm) per year
    - Savings potential – Let's just make some general estimates to determine the direct benefit to a farmer if site specific irrigation was utilized
        - If one could achieve a 10% reduction in water usage by applying water only to the specific areas of the field requiring irrigation, this would equal about a 234 ac-in reduction in the volume pumped
            - This would translate into a reduction in hours the pump is operated resulting in a savings in pumping costs of about $457 (electricity = $ 0.08 / kw-hr
        - As a second case, if one could achieve a 25% reduction in water usage by applying where needed, this would be equal to about a 858 ac-in reduction in the volume of irrigation pumped
            - In this case the savings due to the reduced volume of water pumped in energy costs would be about $ 1,142 (electricity = $ 0.08/kw-hr)

- Potential issues
  - One area of particular concern is the hydraulics of the entire irrigation system. As valves turn on and off, changing the volume being pumped there will be a potential impact due to the pump curve. With most pumps as volume changes so does the pressure. The entire system must be evaluated to determine if the changes will have a negative impact on the pipeline, center pivot or other components.
    - Two solutions could be:
      - Variable speed pump to maintain a constant pressure
      - Monitor the minimum volume pumped to ensure one does not exceed the hydraulic characteristics of the system
  - Another concern is feedback to determine that what is supposed to be happening in the field is what is happening. How does one monitor the field to determine each management zones status?
    - Solution - this is an area requiring more evaluation and research

- Example #2
  - ¼ mile (395m) pivot
  - 121ac (49ha)
  - Corn - typical nitrogen application
    - 230lbs per acre (257kg/ha)

  - Savings potential - Again let's just make some general estimates to determine the direct benefit to a farmer if site specific irrigation was utilized
    - Based on the established management zones we shall consider that a 10% reduction in nitrogen use could be achieved. This would equal about 2,800lbs of actual nitrogen applied.
      - This 10% reduction could save the farmer about $840 (Nitrogen at $0.30/lb)

    - Let's assume a 25% reduction in nitrogen use is possible based on the management zones. This would equal a savings in the amount of nitrogen applied of 6,950lbs.

        - The savings with a 25% reduction would be worth $2,085 to the grower (Nitrogen at $ 0.30/lb)

    - As in the case of the water delivery there are some potential issues.
        - Again the overall hydraulics are a concern as the nitrogen would be carried in the water and has the same issues as in example #1 above.
        - The additional complexity of the nitrogen delivery as one changes for the different zones and a variable rate pump is the most likely answer
        - Lastly the same monitoring issues exist as for the example above for each of the management zones.

- If one combines the potential savings of water, energy and nitrogen to evaluate the overall impact one finds:
    - With a 10% reduction
        - Water savings = 234 ac-in
        - Energy savings = $ 457
        - Nitrogen savings = $ 840
            - Total $1,297

    - With a 25% reduction
        - Water savings = 858 ac-in
        - Energy savings = $1,142
        - Nitrogen savings = $2,085
            - Total $3,227

The first question a farmer will then ask is great – I can potentially save some money but what would be the potential costs to achieve these savings?

Considering only the costs for the software and hardware for the modifications to the ¼ mile center pivot in the examples above, the estimates indicate farmer costs would be in the range of $18,000 to $25,000 for an installed package. Much depends on the irrigation equipment he already has and how much additional hardware is required.

An estimate of the payback would be:

> A 10% reduction in water and nitrogen would require fourteen to nineteen years to payback the investment in the changes to the center pivot and this does not include any costs to modify the water pump or nitrogen injection system
>
> If one could achieve a 25% reduction, the payback would be in the range of five to eight years. Again this excludes any costs to upgrade the water pump or nitrogen injection system.

This raises several questions:

- How is this going to accepted in the market place based on today's economics?
- How achievable would 10 or 25% reductions be?

Also no consideration is given to the possibility of the overall yield and/or crop quality being significantly improved which could also impact the farmer's bottom-line finances.

In the examples using commercially available packages, most utilize standard, proven components without making changes to new technologies.
Some use auxiliary control panels but the main changes are in software and how the information for the management zones is 'loaded' into either the auxiliary or center pivot control panel.

Based on the findings so far there are a number of areas requiring additional work and evaluation to help move site specific irrigation forward. Some of these would be (but not limited to):

- Optimum economic size of management zones
- Methods to efficiently provide the farmer easy control changes to the management zones
- Methods to obtain easy feedback from the management zones and incorporate into the farmer's decision making tools
- Impact to crop quantity and quality
- Methods to place a value on some of the possible soft benefits such as water savings, runoff, ground water impact and others

Conclusion: Historically center pivot irrigation has treated the entire field the same. Changes in center pivot control technology have occurred which allow growers some limited ability to apply differing amounts of water and products carried in the water to different sectors of the field. This paper has reviewed the commercial advancements and the current status of the market for site specific irrigation. Current hardware for center pivots is easily adapted for site specific use. Only in the area of software does there appear to be significant additional development requirements. Indications based on today's economics indicate payback in the best cases of five to seven years and possibly much longer. In this paper only the impact from the reduction in pumping costs and nitrogen required has been considered. Much more work is required to better develop the economic benefit of site specific irrigation particularly in the areas of monitoring the performance of management zones. Additionally consideration must be given to how one thinks of center pivot irrigation and the overall goal may not be to achieve general field uniformity but to apply the water and other crop inputs to the particular area of the field with the requirement.

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