Growing Rice with Pivots – A Step Towards Water Conservation

Werner Arns, Farm Manager & Herbert Arns, Agronomist

Traditionally, rice has been grown using surface irrigation worldwide. Fields planted with rice are flooded with water and remain flooded for the growing season. One of the primary functions of the standing water is to control weed growth. While this practice has proven successful for centuries, the availability of water is becoming scarcer with each growing season.

In an effort to conserve some of the water designated for agriculture, an experiment has been conducted over the past seven years in Brazil on the feasibility to grow rice under mechanical move irrigation using a center pivot instead of surface irrigation. If successful, a large percentage of water could potentially be saved.

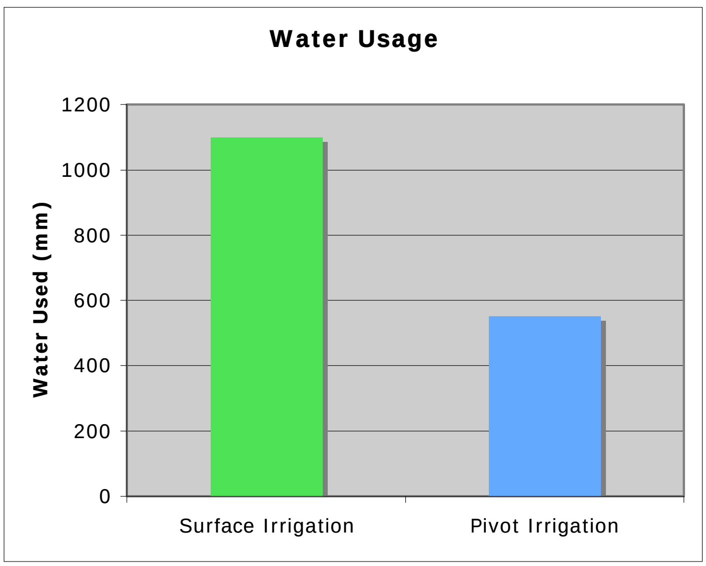
Werner Arns, a farmer in the Rio Grande do Sul region of southern Brazil, and his cousin Herbert Arns, an agronomist, started experimenting with mechanical move irrigation on their rice crop in 1999. For the previous 24 years, they had been surface irrigating. Between land they own and land they rent, they are farming a total of 1600 hectares per year. They were starting to experience water shortages in their area, a problem that is becoming more common worldwide every year, and felt they needed to make some significant changes if they were to remain profitable growing rice. With the use of a single span, 3 hectare Valley center pivot, the Arns' began mechanically irrigating their field.

From the beginning quite a few adjustments had to be made to their crop inputs. The Arns' consulted with Syngenta and other institutes to determine which of their traditional inputs would need to be increased or decreased due to the absence of standing water. The institutes concluded that the Arns' should increase planting densities and reliance on herbicides during the early growing season to control the weeds, as well as increase the fertilizer applications due to the higher plant population. The seeds also had to be pretreated with fungicide and insecticide to prevent the decay of the seed and discourage insects from attacking the seed.

The Arns' used many of the same herbicides and insecticides that were used for their surface irrigation operation. The herbicides used include: GAMIT 500 CE, Ally 600, FACET PM 500, and Sirius 250 Sc. The insecticide and fungicide used were Pounce 380 CE and Dithiobin 780 PM, respectively. GAMIT 500 CE was applied in the pre-emergent stage of the rice crop, and then FACET PM 500 and Sirius 250 Sc were applied 25 days after the emergence of the rice.

Just to make sure that they were maximizing the crop's potential; the Arns' experimented with different seed varieties, densities, and application rates of fertilizers and herbicides on various plots underneath the pivot. Over the years, they identified the seed varieties that produce the highest yields. The Arns' have settled on using seed varieties that have a strong resistance to disease and mature in 130 days. They have also discovered that they do not need to plant as densely as was thought back in 1999. In 1999, they planted 200 – 250 kg/ha of seed, but currently they have adjusted the seeding rate to 100 kg/ha (the average seeding rate for surface irrigation), and are going to test planting at 80 kg/ha during the next crop rotation. They will also experiment with hybrid rice to see if there are any production advantages to using it over conventional seeds.

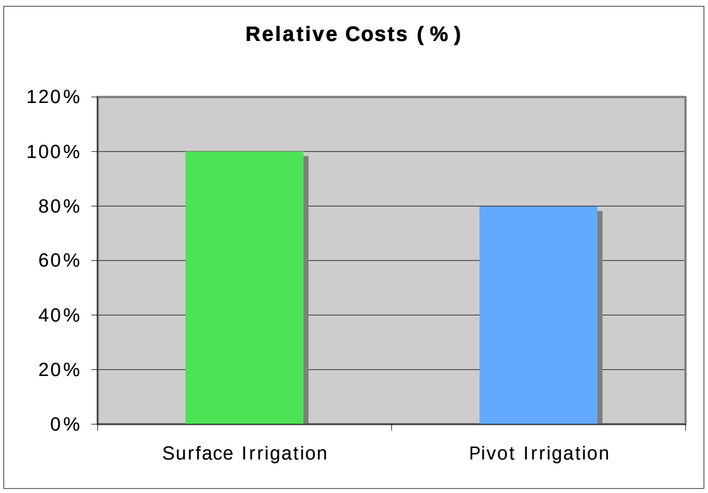
The biggest driver to switch to pivot irrigating rice was to save water. Compared to surface irrigation, the Arns' reduced their water use for irrigation by over 50% due to the ability to better manage the water applied to the field with the center pivot. With surface irrigation, the annual application depth was 1100 mm, and now with pivot irrigation, it is a maximum of 550 mm. The center pivot has allowed for even more conservation in the spring months (October-November), when the Arns' only need to irrigate every 2-4 days due to the temperate climate. Because they can manage the soil's moisture deficit with a center pivot, they know that they will apply an average of 8mm each day they irrigate.



Another advantage when using center pivots to grow rice is that it allows the Arns' to rotate crops multiple times a year, adding valuable nutrients to the clay soil and improving the soil's quality. This was never possible with surface irrigation because of the amount of labor necessary to convert the fields from rice to another crop. Today, under center pivots, the Arns' crop rotation is as follows: rice, wheat, soybeans, rice, oats, and soybeans. This extensive rotation is possible since there is little that needs to be done in terms of land preparation. They have also discovered the benefits of practicing minimum tillage which has lead to saving time, reducing runoff, and protecting the soil's productivity. The advantages of crop rotation and minimum tillage have allowed them to bring organic material back into the soil, reducing the high levels of compaction it has experienced from 30 years of growing nothing other than rice, and improve the soil's quality.

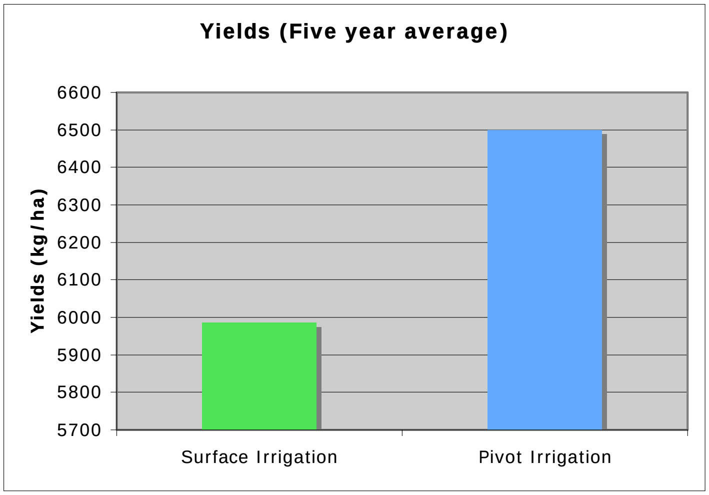
Over the years, the Arns' have carefully tracked their expenses when irrigating with both surface irrigation and center pivots. Besides the 50% water savings that they have realized with center pivots, there has also been a dramatic decrease in production costs. The following reductions have been realized since they began irrigating with pivots:

Land Repair……………………………….3.07%
Heavy Tillage……………………………..4.55%
Field Leveling……………………………. 2.86%
Drain Water……………………………….2.89%
Surface Smoothing………………………..0.18%
Canal Construction……………………….2.56%
Dike (Construction and Maintenance)………4.01%
TOTAL……………………………………...20.12%

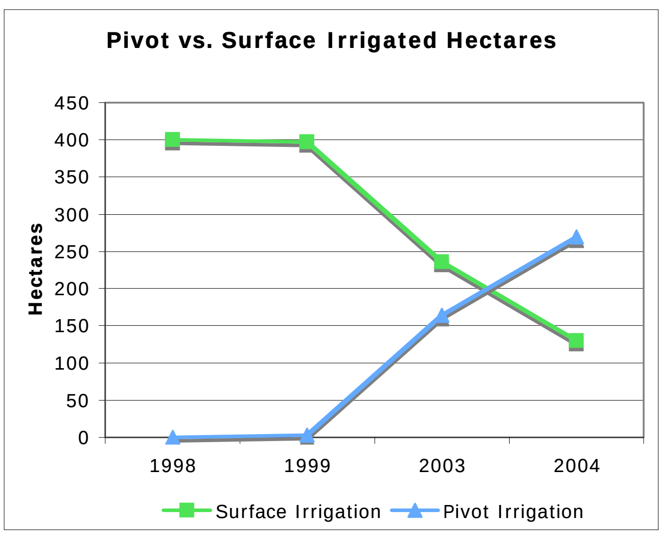


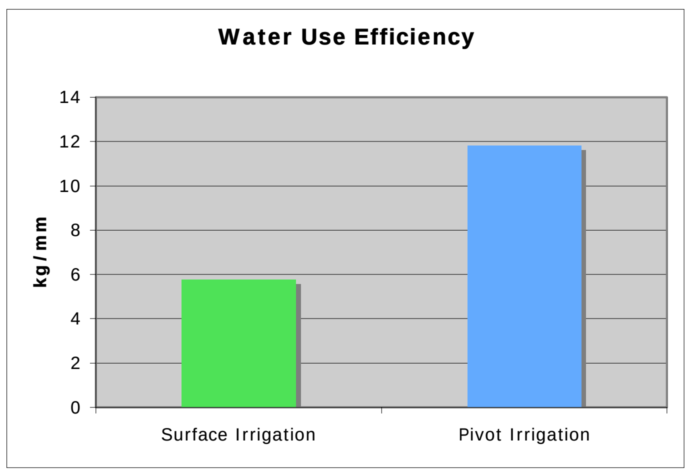
The Arns' also tracked the soil characteristics both before and after irrigating with center pivots. The soil readings in 1999 showed that there was only 2% organic material in the top 10cm of the soil profile, and the pH was 5.6. They continued to take readings each year, and as of 2006, they showed that the organic material had increased to 3% and the pH increased to 5.9, indicating that crop rotations, minimal tillage, and the lack of standing water had a positive effect on the soil itself.

Ultimately, due to the elimination of some production practices and the improved quality of the soil, the Arns' have been able to harvest at least 6500 kg/ha of rice each year, while the yield in 2006-07 in Rio Grande do Sul was 6350 kg/ha. They have also been able to reduce water pumping requirements by over 60%, soil preparation, and tillage operations. Despite some increases in crop inputs, their savings and comparable yields have far outweighed the added costs.



Due to their success, the Arns' have gradually expanded their rice production to field scale production with center pivots. They have purchased three more center pivots and have intentions to purchase even more center pivots in the future. With their current savings, they can expect to pay off each machine in five or six years. They will also experiment with applying less water than they are currently using to see if they can produce similar yields. Since seeing the results of these experiments, Werner Arns has become an advocate for center pivot irrigation, knowing that the water savings alone can help reduce a crisis that is sure to occur if people continue to surface irrigate as they always have.





RICE PRODUCTION USING CENTER PIVOT IRRIGATION – A CASE STUDY

Valmont Industria E Comercio LTDA
Uberaba/MG – Brazil,
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Introduction

Rice is one of the world's most fundamental food crops. Historically, rice was considered to require relatively large amounts of water, in comparison with other types of grains, as part of its traditional production process. With water shortages becoming ever more frequent in many rice producing areas around the world, other growing techniques are being explored in an effort to reduce fresh water requirements, improve production, and increase overall economic return. This paper provides a brief description of one approach that has been successful in meeting these goals using non-traditional production methods and high-efficiency irrigation.

Background

Traditional rice growing methods include the use of vast quantities of water to flood irrigate rice fields. The rice fields are typically divided into individual units which are bermed and contoured to control water movement across the field. While some of this water is consumed by the crop, the vast majority of it is used as a form of weed control (i.e., the rice plant will survive under saturated conditions while many weed species will die). Typical rice growing production steps usually include heavy tillage, leveling, surface smoothing, channel preparation, berm construction, planting, flood irrigating (multiple events), draining, and harvest. While traditional growing methods have a long proven history of success, the soil and land management components can be costly and the volume of water needed for its successful implementation may be limiting in many areas.

Photo 1: Brazilian Rice Production

In the rice growing region of southern Brazil, water shortages have become a reality for many rice farmers. In the case of Mr. Werner Arns, who owns over 1,000 hectares (ha) of agricultural land, these water shortages resulted in only having about 1/3 of his ground in rice cultivation during any one growing season. Knowing that the water shortages in his area would only increase in severity, Mr. Arns consulted with Valmont Industries (**Valmont Industria E Comercio LTDA**) and Syngenta (**Syngenta Seeds LTDA**) for irrigation and crop management assistance. Mr. Arns was willing to participate in a demonstration project using unconventional rice growing methods following the suggestions provided by these two firms.

Demonstration Project

At the beginning of the demonstration project, Mr. Arns was provided with a single span center pivot system by Valmont Industries that would sprinkle irrigate approximately 2 ha of ground. Working with Syngenta, Mr. Arns experimented with different seed varieties, seeding densities, and fertilizer/herbicide application rates on various plots under the pivot. Since flood irrigation would not be used, increased reliance upon herbicides during the early growing season needed to be incorporated into the demonstration for weed control. However, since it became apparent that deep tillage would not be needed and that overall land preparation requirements would decrease. Given the reduction in, or elimination of, annual leveling, surface smoothing, channel preparation, and berm construction, most of which became unnecessary with the mechanical move sprinkler irrigation system, the increased usage of herbicides appeared a reasonable tradeoff. Syngenta also suggested that the planting density be increased as an added form of weed control as well as to experiment with potential yield increases. The demonstration pivot was operated over several seasons to refine the planting and growing techniques that could be implemented on a commercial scale.

Photo 2: Field Preparation

Observations

Mr. Arns was able to make the following observations during the field trials conducted using the single-span center pivot:

1) The center pivot was able to provide an adequate amount of water for crop consumption whereby minimizing the total volume of water needed for rice production. Comparable rice production could be realized using up to <u>2/3 less</u> water than conventional methods.

2) Since channels and berms associated with flood irrigation were no longer needed, the total surface area dedicated to crop production could be increased.

3) It was determined that the rice seed would germinate and grow without the need for intense soil tillage and surface preparation. Minimal tillage techniques were employed at the site with direct seeding only.

Photo 3: Pivot Irrigation on Newly Seeded Field

4) The minimal tillage approach resulted in increased organic matter in the surface soil profile which will reduce erosion and be more protective of the soil's tilth and productivity.

5) By minimizing the surface preparation requirements and improving harvesting speeds (the harvest could be completed quicker since the soil was not saturated by flood irrigation), more than one crop could be produced in a year (i.e., Mr. Arns

was able to produce 2 rice crops and 2 soy bean crops in 2 years).

6) Seeding rates needed to be increased to a 200 to 250 kg/ha range. As a comparison, directly seeded rice is typically planted at a rate ranging from 100 to 100 to 150 kg/ha on a global basis (U of A, 2005).

7) The increased plant density increased the fertilizer requirement (e.g., more plants needing more nutrients) to about 160 kg-N/ha, 75 kg-P_2O_5/ha, 80 kg-K_2O /ha.

8) The seed needs to be pre-treated with fungicide and insecticide.

9) The reduced soil preparation, water pumping requirements, and water distribution efficiencies provided by the center pivot system resulted in a significant energy savings.

10) This alternative production approach was able to raise the net rice yield to 6,500 to 8,000 kg/ha. As a comparison, Brazilian rice yields averaged 3,550 kg/ha in 2004 (FAOSTAT, 2005).

Photo 4: Emergent Rice under Pivot Irr igation

Economic Implications

The economic implications from this project were assessed on a production cost basis. Mr. Arns estimated an overall production cost reduction of greater than 20% associated with land management requirements (e.g., heavy tillage, leveling, smoothing, canal and dike construction, etc.) in utilizing center pivot irrigation over the traditional use of flood irrigation.

On a nationwide basis, Brazilian rice production costs have recently approached R$600.00 per MT of rice produced (USDA, 2005). Under the traditional growing method, this equates to approximately R$2,100 per ha of planted rice. Although the initial 20% production savings, as shown above, was offset by the increased fertilizer and herbicide expenditures, Mr. Arns realized additional cost reductions by decreasing his overall energy requirements (i.e., pumping costs per ha irrigated was reduced by 2/3^{rds}) while the overall farm income increased with improved yields (i.e., the net yield per ha doubled). It is estimated that the fertilizer and herbicide requirements will decrease over time as the overall soil tilth and organic matter concentrations increase with each successive crop rotation that utilizes minimal till soil preparation techniques. Mr. Arns has since purchased three 80-ha pivot systems which Mr. Arns estimates has a 5-year or less return value.

Photo 5: Rice under Pivot Irrigation

Conclusions

Rice production using center pivot technology has been shown to be successful in reducing water consumption, improving soil erosion control, and minimizing soil preparation inputs while increasing yields. As shown by this case study, rice can be successfully grown using center pivot irrigation by implementing the following protocols:

- Selecting and experimenting with different seed varieties
- Direct seeding at increased seeding rates
- Following minimal till practices
- Implementing an appropriate herbicide program for weed management that is protective of the environment
- Applying fertilizer in a responsible manner to supplement the increased plant density and yield

Photo 6: Rice under Pivot Irrigation

The benefits of utilizing this approach for rice production regions around the world can include:

- Reduced irrigation requirements
- Expanded agricultural capacity
- Field versatility (i.e., other crops can be planted and grown on rice fields as an alternative or within a rotational scheme without making significant changes to the field's infrastructure)
- Minimized energy usage
- Increased yields
- Less soil preparation
- Improved soil conditions
- Reduced soil erosion
- Added protection against surface water contamination from agricultural runoff and flood irrigation water return (i.e., agricultural runoff can be minimized or eliminated with a properly managed center pivot system).
- Reduced field infrastructure development cost.

Photo 7: Second planting using seed drill

On a global basis, this rice production approach has the potential to provide rice growing opportunities to many regions that may have previously been restricted by soil or water limitations.

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More Options with Valley® Pivots on Rice

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When Werner Arns and his brother Walter took over their father's farm, growing rice meant growing only rice on flood-irrigated ground. Werner says "If I did flood, I had to till my ground and prepare my ground for leveling in such way that I could only do one crop a year. And then I was in a very bad monoculture for my soil and also for my pocket."

Werner Arns is a man who tries to look for the other options for his situation, so he started experimenting on something that isn't done much anywhere in the world. Five years ago on his farm in Rio Grande do Sul, Brazil, he and Walter started some small experiments with sprinkler irrigation on rice. He compared solid set irrigation to flood irrigation on rice. Seeing a little success in this process, he moved on to center pivot irrigation, with the help of Arno, Rainer, and Mariane Schollmeier of Pivotsul Engenharia da Irrigacao LTDA. Pivotsul provided Mr. Werner with a borrowed test pivot, a 3 ha (7.4 acre) system.

In comparison to the solid set irrigation, the small pivot provided even better results. The reasons, according to Arns, were because he had better control of the moisture, and wind wasn't as big a problem. The application of water was much more uniform. "So with this small pivot, I could really start to test three seed varieties to see how they reacted in relation to the quantity of water that I was applying."

Under the small pivot, the yield was just as high as on the regular flooded area. The big difference, of course, was only using one-fourth of the water.

In 2003, Werner and Walter Arns each invested more into pivot irrigation. Each brother purchased an 80 ha (198 acre) Valley center pivot.

Using the 80 ha pivots, Werner had two varieties of rice. One yielded 6.900 kilos/ha (6158 lb/acre) and the other one produced 7.300 kilos/ha (6515 pounds/acre). The average yield in this area runs from 5.800 (5177 lb/acre) - 6.000 kilos/ha (5355 lb/acre) on flood irrigated farmland.

Arns says these were very good yields, but still believes there is room for improvement. On future crops, he'll experiment with using less seed per hectare. He thinks allowing more space between plants may create better yields, since it's easier to control seed placement on soil that's not flooded.

Not having flooded ground also allows for more crops per year, because the land does not have to be tilled and leveled between crops. "With the pivot, no doubt I can make at least two crops a year, and maybe even 5 crops in two years," says Werner Arns, "but a minimum is definitely two crops a year. I will do no tillage or at least very little tillage, not destroying the soil and not having to always compose it again, to bring it to a better yield potential." Planting two crops allows Arns to put more organic material into the soil. Besides saving water, his biggest argument for pivots, and his biggest benefit from them is definitely the crop rotation.

Considering that he has zero subsidies from the state to be a rice grower, Arns says "the advantage is that I can water 3 times more land with the same amount of water. Also, from an environmental standpoint, no till farming is better for the soil and my financial situation." Arns says being able to grow more crops in one year, he can definitely improve his cash flow and make his whole farm more prosperous. "With all of the other investments in machinery and so forth that are needed, the pivot is the only critical tool bringing me to the stage of being able to diversify. There's no doubt that even with all of the other investments necessary, they'll all pay for themselves in five to six years."

And there's a lot still on Werner's shopping list. He needs a different planter, and maybe a bigger combine. Also, once he's attained a better cash flow he wants to purchase storage structures on his farm, rather than having to sell at harvest time. The pivot gives Werner Arns the power to completely change the economics of his farm.

Irrigating rice with pivots is a dramatic change in technology. Conventional wisdom holds that it must be flooded for proper weed control. And what about getting a pivot through such wet soils?

Arns says the weed control wasn't a problem. He says the center pivot actually allowed for more precision application herbicides. Pre-emergent herbicides were applied and Arns was able to activate them on schedule with the controlled application of water from the pivot. He expects the future, he'll be able to be even more precise with chemical application, with both herbicides and insecticides, saving additional input costs.

Wheel ruts have been a challenge for this grower, and he's exploring options for making the situation better for future rice crops under Valley pivots. Arno Schollmeir of Pivotsul recommends wider tires. The first year he used 12.9 24” tires, and it's been recommended he try 16.9 x 24” for the next pivots he wants to buy.

Since the soil is very clayey and compacts easily, the dealer recommends that he definitely do some maintenance on wheel tracks, perhaps building up the soil where the wheel tracks are formed. With time and experience, use of the Valley V-3 Drive may prove useful in this application. An additional option is using directional sprays, to keep the water away from the tracks. This process might take a little work, but Mr. Arns is still focused on the labor savings of the whole equation. In a typical flood irrigation season, he would need two people per 70 ha (172 acres) of cropland to manage the irrigation early in the season. About a third of the way through the growing season, he'd be able to cut back to one employee per 70 ha. This is a lot of labor. If he increases his pivot population to 6 or 8 pivots in the future, one person would be able to manage all of the irrigation for the season, even without using Valley's most automated
pivot control panels.

For now, the experiments will continue, getting broader in scope. For the next growing season, he will continue to experiment with fertilizer use, seed population, and irrigation amount to determine optimum management needed for this new system. He's also interested in sharing the results of his studies, and hearing from other growers who may have experimented with pivots on rice. Werner Arns can be reached at Werner.arns@brturbo.com