# Boom-Type Carts vs. Big-Guns in Northwestern Washington

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**Abstract.** *Agricultural producers in Northwestern Washington need an irrigation system that is low-cost, non-permanent, and highly mobile to provide supplemental irrigation water to certain crops. Big-guns on reels fill this need. Recently a few progressive growers have been experimenting with boom systems. These can work with the existing reels but use long "booms" cantilevered over both sides of the cart to distribute water through drop tubes similar to a center pivot. This paper will discuss the system performance comparison evaluations for efficiency and uniformity for both of these systems. The economics and practical considerations of converting from a big-gun to a boom are also discussed along with how this will impact the environment.*

**Keywords.** Big gun, boom, economic comparison, efficiency, uniformity

*Ag. and Natural Resources Extension Agent, Don McMoran measuring the volume in a catch can with a boom irrigation system in the background.*

## Introduction

Irrigation in Northwestern Washington is done on a supplemental basis. Although there have been years in the past when farmers have not used their irrigation equipment, (1996 growing season) these years are becoming fewer and further in between. Using the WSU Skagit County Extension Agriculture Statistics, WSU extension personnel have noticed a rise in supplemental irrigation in Western Washington using what is referred to as a traveling, or reel big-gun system (Picture 1). This system of irrigation is effective at supplying water to the crop but applies water inefficiently. High pressures are required to propel the water long distances. Therefore it is highly vulnerable to wind drift and evaporation. Addition tests have shown that big gun systems have poor distribution uniformity when compared with other systems.

Picture 1. A big-gun irrigation system in operation.

Improved irrigation efficiency and distribution uniformity are important because they can improved crop yields, crop uniformity and quality, and can facilitate fertigation or chemigation. These improvements can also lower input costs of irrigated specialty crops in Northwestern Washington such as high value vegetable seed crops, small fruit and potato production while addressing environmental concerns for conserving water and energy.

Recently manufacturers have adapted the reel big-gun to a boom system (Picture 2). Similar to a reel big-gun, a "boom" system is mounted on a traveling cart that is reeled in slowly over a length of a field. However, "booms" (supported pipes) are cantilevered over both sides of the cart and micro sprinklers are spaced along the length of the pipe to evenly distribute water over the soil similar to center pivot or linear-move irrigation systems. Because of the different mode of operation, a boom system operates at lower pressures and the water travels less distance through the air. This should make the irrigation system more efficient (less water is evaporated as it travels to the soil surface) and should make it less susceptible to wind redistribution. Therefore one would expect higher distribution uniformity.

Picture 2. A boom irrigation system in operation.

The objectives of this project were to compare uniformity and water application efficiency of typical big-gun irrigation systems with a new boom type irrigation system and to look at the cost advantages or disadvantages of each system.

## Materials and Methods

Evaluations were done on two big-gun systems, and on two boom systems. All of the evaluations were done in potato fields. Standard procedures for doing irrigation system evaluations were followed. A line of catch cans was laid out at equal intervals ahead of the traveling sprinkler perpendicular to its path in an un-irrigated area of the field. The cans were placed on the top of the bed of every third row in line with the plants. The can's position in relation to the center line of the traveling sprinkler was noted. The cans were placed as level as possible and the plant canopy was laid down away from the can if it was likely to interfere with the trajectory of the sprinkler drops as they traveled from the sprinklers to the catch cans. The system was allowed to pass completely over the row of cans until water was no longer being caught in the cans. The volume of catch was then measured in each can and recorded along with the can's position. This volume was converted into an application depth using the cross sectional area of the can opening.

The travel speed of the sprinkler was measured using a long survey tape, marked beginning and ending locations, and a timer. This measured speed was compared with the travel speed information on the reel controller as a back-up check. The pressure was noted at the sprinklers as well as at the reel and if possible at the pump. Wind conditions were recorded. The water flow rate going into the reel was measured using a portable transit time ultrasonic flow meter. The catch depth, the spacing between the cans and the travel speed of the cart was used to calculate the water application rate at the soil surface. This was divided by the measured inflow rate to calculate irrigation application efficiency. Application efficiency is the percentage of the water leaving the nozzle that makes it to the ground to be stored in the soil (assuming no runoff).

The catch depths from the border cans were added to simulate overlap from previous and subsequent pulls. These catch depths are ordered and the average of the lowest 25% is divided by the overall average catch to give the distribution uniformity of the low quarter (DULQ). DULQ is a number between zero and one that reflects how evenly the irrigation system applies water. The lower the DULQ the more water must be applied to adequately irrigate all areas of a field to compensate for the fact that some areas aren't receiving adequate water.

# Results

## Big Gun Evaluation 1

This was done on a Baur reel and gun. Wind speed of about 10 mph out of the northwest was estimated. The rows are oriented in a north-south direction. The pressure at the pump was 140 psi. Because, the reel was run by a hydraulic drive the pressure was reduced across the drive. The pressure at the nozzle was 100 psi. The big gun was pulled from the south towards the north. Potatoes were grown on 36 inch centers and the grower was irrigating 90 rows per pull for a total an irrigation width of 270 ft per pull. The depth of water caught in each can at various distances from the center line is shown in figure 1. During the evaluation, the wind had a large effect on the uniformity and efficiency of the gun. The wind was likely responsible for not only distorting the pattern to one side, but also tightening the pattern so that the outer edges didn't receive as much water as they should. If the exact same application pattern is seen every pull, then the current overlap strategy of 90 rows would result in the pattern shown in figure 2. An improved overlap strategy of irrigating only 65 rows per pass is shown in figure 3. This overlap strategy would give a much better water distribution uniformity. In general narrowing the distance between passes assures good irrigation uniformity regardless of the wind condition. This would result in improved yields and crop quality. The efficiency of this system was estimated at 58%. In other words, 58% of the water that left the nozzle made it to the soil surface.

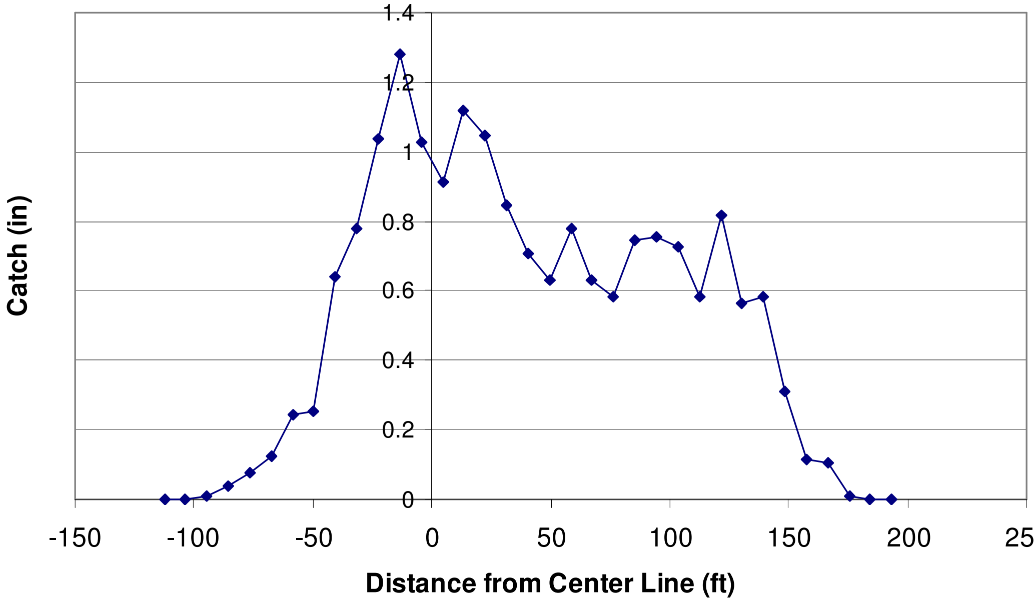

Figure 1. The catch of big-gun #1 at various distances from the center line.

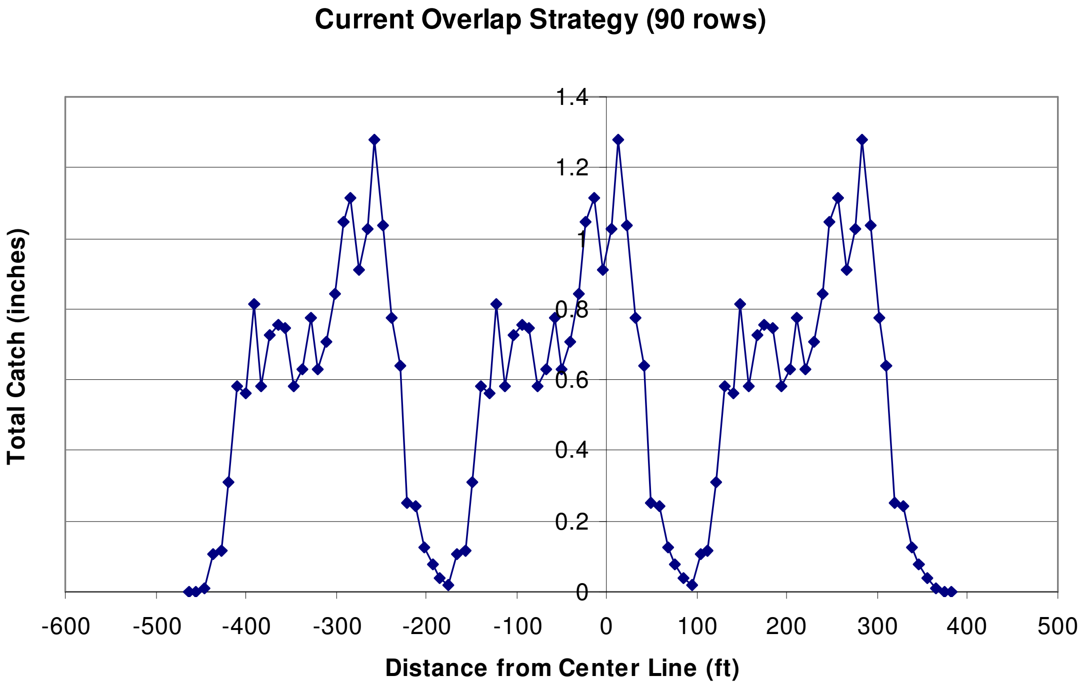

Figure 2. Three overlapping pulls if the exact pattern is replicated on a 90 row spacing resulting in a $DU_{LQ}$ of 0.20.

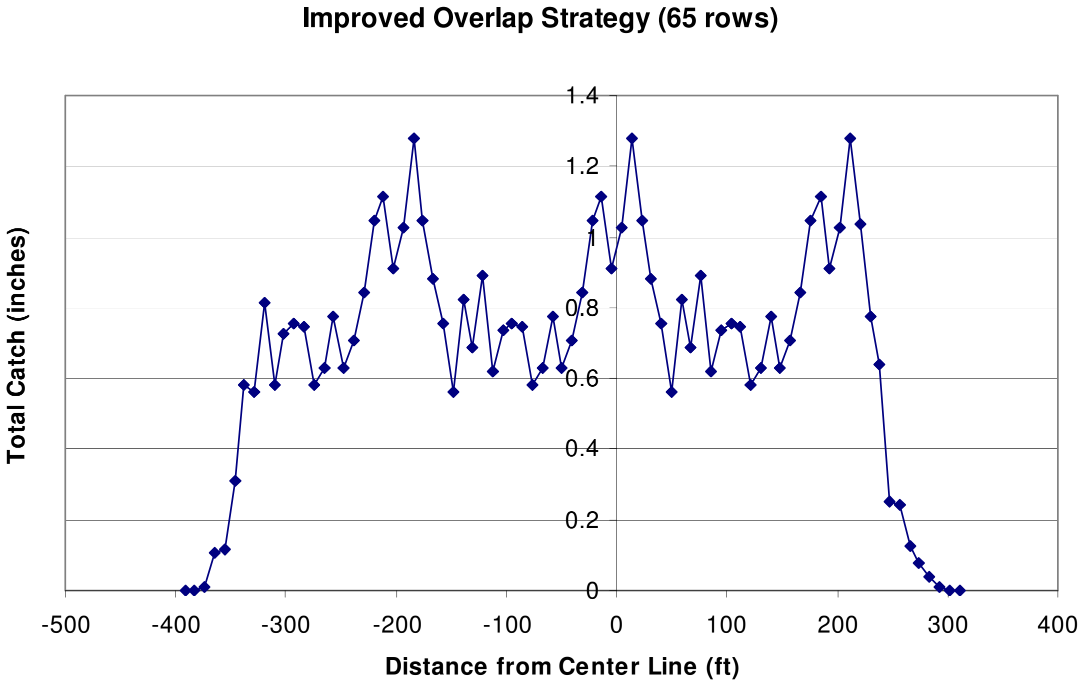

Figure 3. Three overlapping pulls if the exact pattern in replicated on a 65 row spacing resulting in a $DU_{LQ}$ of 0.75.

## Big Gun Evaluation 2

This evaluation was done on a Rainstar reel (Model E51) and a Bauer gun. The application rate was set high on this gun such that too much water was caught in the cans, resulting in lots of splash-out and overflow. Because of this inaccuracy we can't report the results from this evaluation. Another similar evaluation was done earlier in the year on a big gun by Tom Walters in which he reported a DULQ of 0.73 for the overlapping portions of his evaluation.

## Boom Evaluation 1

A Baur Rainstar reel (model E31) was used in this evaluation. The boom was also manufactured by Bauer. The reel was driven by a small gasoline engine. The system pressure was 58 psi at the pump and 45 psi at the reel. This was regulated at the boom nozzles to 20 psi. Instead of just one row of cans, two rows were used to improve the accuracy of the catch estimates. The catch can results are shown in figure 4 and the current overlap strategy would result in the application pattern in figure 5. The grower was struggling with the pressure regulators plugging up. This was apparent from the evaluation data. The low catches next to the center line were the results of partially plugged pressure regulators. A low catch followed by a high catch was also observed at the ends of the boom. The grower subsequently changed the nozzle configuration at the ends of the booms to decrease the over application at the ends and improve the uniformity underneath the ends. Figure 6 gives the potential application efficiency and uniformity of this system after these two minor issues were corrected. The efficiency of this system was estimated at 86%.

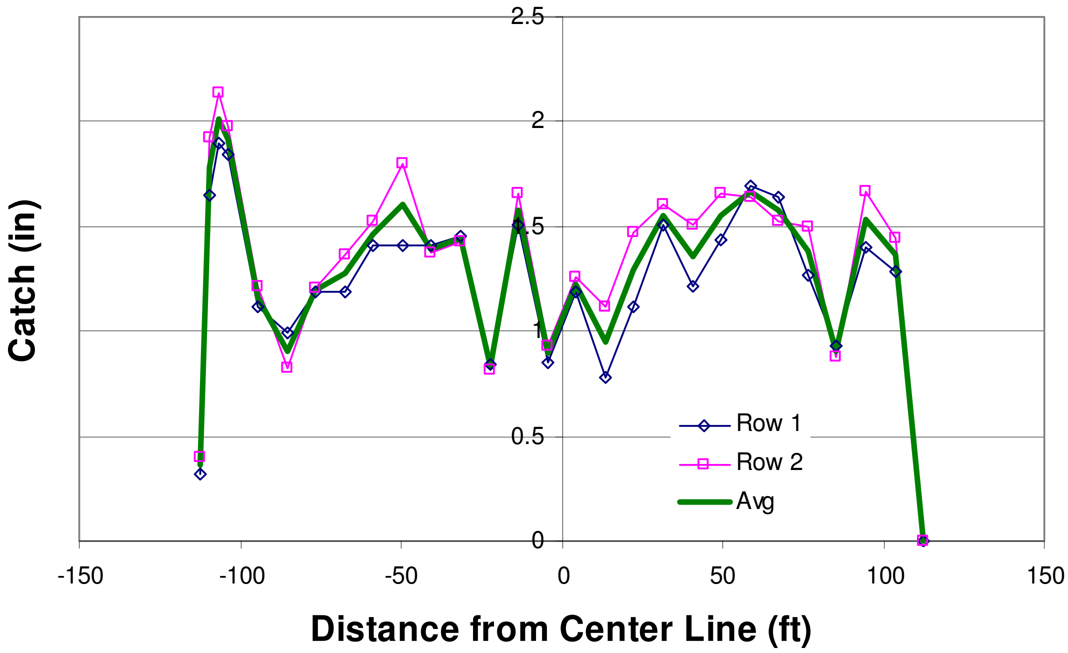

Figure 4. The catch of boom system #1 at various distances from the center line.

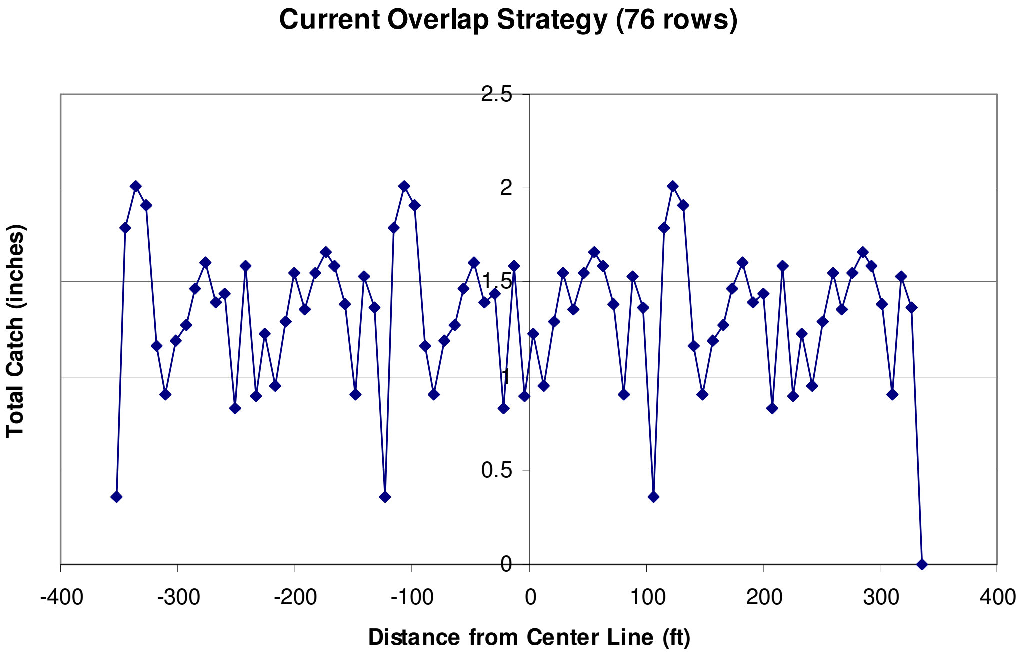

Figure 5. Three overlapping pulls of Boom 1 if the exact pattern is replicated on a 76 row spacing resulting in a $DU_{LQ}$ of 0.64.

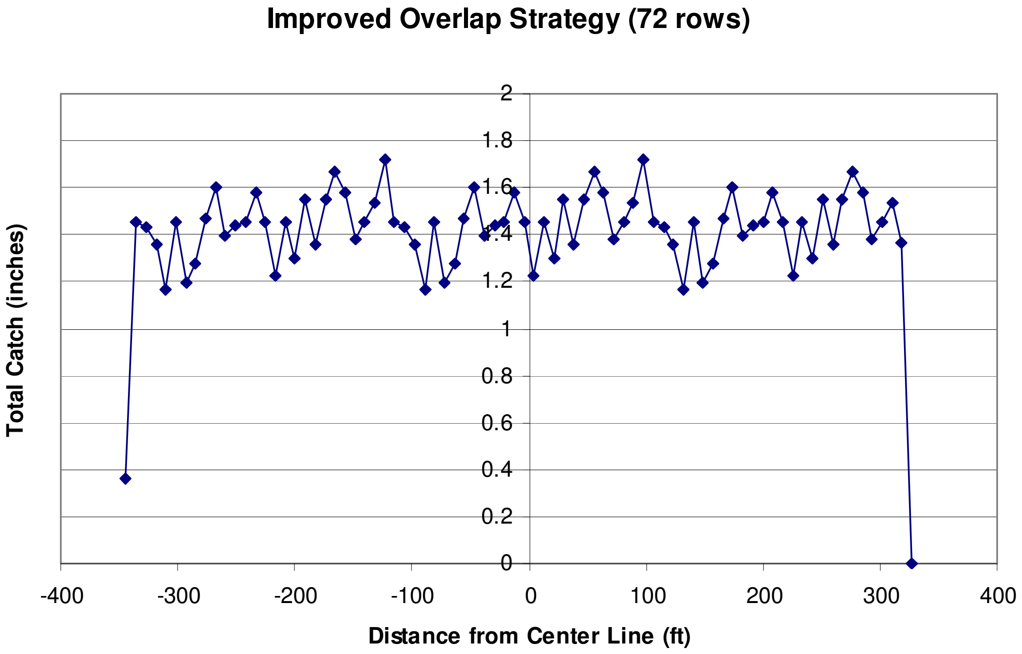

Figure 6. An improved overlap strategy for Boom 1 of 72 row spacing and with the fixing of plugged nozzles resulting in a $DU_{LQ}$ of 0.88.

## Boom Evaluation 2

This was done on a Greenseeker reel and the boom was manufactured by Briggs. The reel was driven by a small gasoline engine. Pressure at the pump was 100 psi (much more than necessary) and was regulated at the boom nozzles to 20 psi. The catch can results are shown in figure 7 and the current overlap strategy would give the application pattern in figure 8. Figure 9 gives the potential application efficiency and uniformity of this system on a 78 row spacing. The efficiency of this system was estimated at 85%.

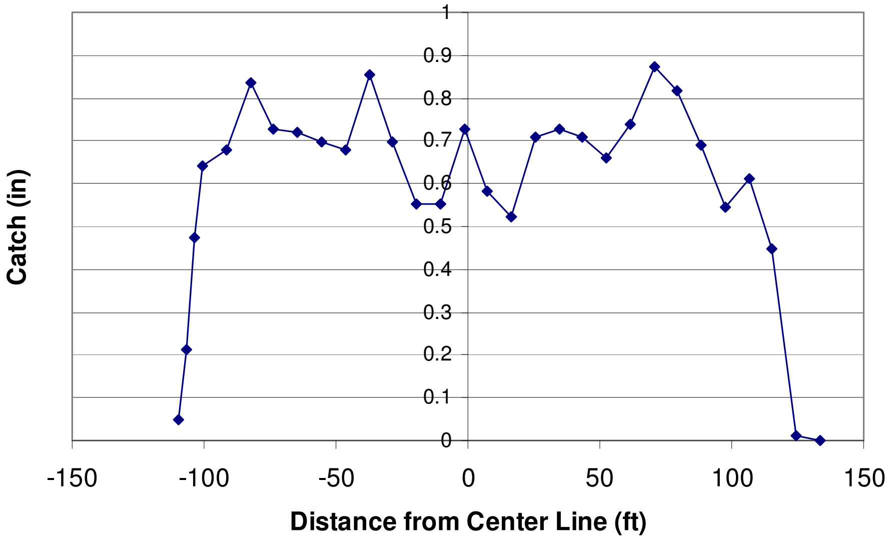

Figure 7. The catch of boom system #2 at various distances from the center line.

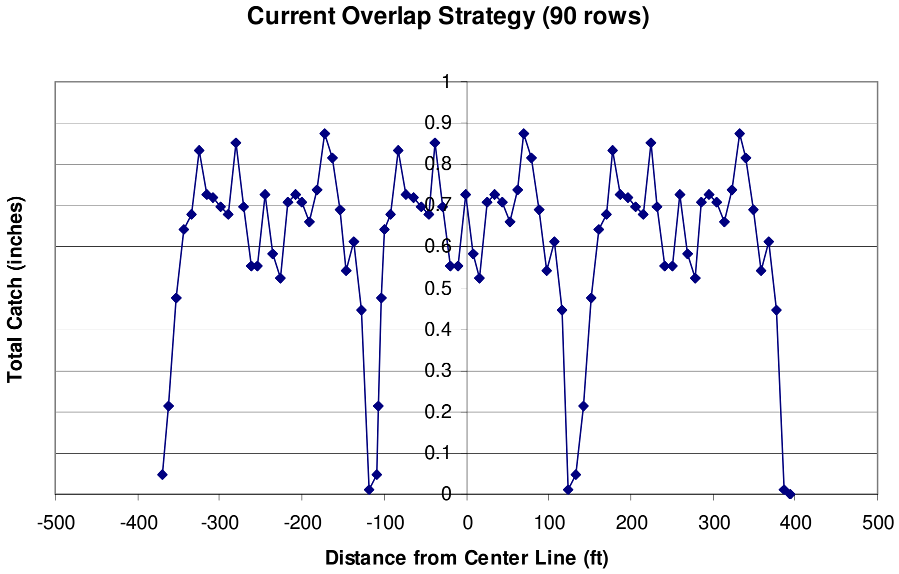

Figure 8. Three overlapping pulls of Boom 2 if the exact pattern is replicated on a 90 row spacing resulting in a $DU_{LQ}$ of 0.53.

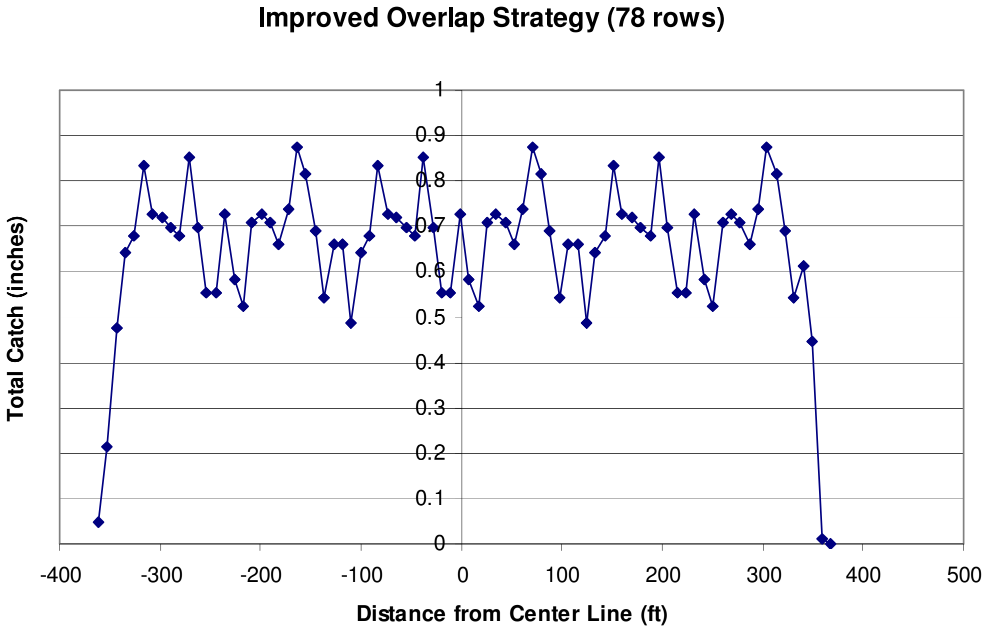

Figure 9. An improved overlap strategy for Boom 2 of 78 row spacing resulting in a $DU_{LQ}$ of 0.81.

## Summary of Results

The results and comparison of the results is summarized in Table 1. Since the objective of the study was to compare a big-gun to a boom system the DULQ that would have been possible with good overlap and without plugged nozzles is also given for both systems and should be the basis for making comparisons between the two systems.

Table 1. Summarized Results

| | **Big-gun 1** | **Big-gun 2** | **Boom 1** | **Boom 2** |
|---|---|---|---|---|
| **Efficiency** | 58 | 60 | 86 | 85 |
| **Evaluation $DU_{LQ}$** | 0.20 | 0.57 | 0.64 | 0.53 |
| **Possible $DU_{LQ}$** | 0.75 | 0.86 | 0.88 | 0.81 |
| **Pump Pressure (psi)** | 150 | 130 | 55 | 100 |
| **Possible** | 150 | 130 | 55 | 35 |

The efficiencies and distribution uniformity numbers for the big-gun evaluations and boom systems are consistent with what was expected. A typical efficiency for a big-gun irrigation system is about 60%. Since their water application method is essentially the same as a center pivot a boom was expected to have efficiencies in the same range as a center pivot (80-85%) which is what was measured. Therefore, on a boom system 42% more usable irrigation water is delivered to the soil compared to a big gun. A big-gun is inherently less efficient because the water spends so much time traveling through the air before it reaches the soil. Water droplets from a big-gun typically spend about 3 seconds traveling through the air. This gives much more opportunity for water to evaporate on its way to the soil. It also gives the wind more opportunity to distort the application pattern. Although under ideal conditions the distribution uniformity of both systems was comparable, the big-gun is much more susceptible to poor uniformity due to higher wind conditions than the boom system was. It was also interesting to note that in all cases (big-gun and boom) uniformity could be very significantly improved by increasing the overlap by just a few rows. This may be equivalent to one or two extra pulls per field.

## Economic Comparisons

Although a boom cart costs significantly more than a big-gun cart, there are potential cost savings because it runs at lower pressure. Energy costs are directly related to pressure and flow rate. If the pressure is cut in half then the energy costs can be cut in half (assuming that the pump is changed so that equivalent pumping plant efficiencies can be obtained). Not only will this result in lower seasonal energy bills but it will require less expensive pumps (lower horse power). Pump horsepower can be reduced since less water must be pumped per unit area irrigated due to higher application efficiency of the boom system.

An analysis was done to compare potential costs of both a big-gun and a boom system for a typical grower in North Western Washington. An electrical pumping plant was compared with a diesel engine pumping plant. The following assumptions were made for both systems regardless of whether it was a big-gun or a boom:

- Water lift from the water source to the pump of 20 ft,
- Flow rate of 350 gpm,
- 100 acres are irrigated per system,
- Seasonal irrigation requirement of 6 inches,
- Power transmission efficiency from motor to pump of 95%,
- Water pump efficiency of 80%, and
- Electrical motor efficiency of 85%, diesel motor efficiency of 33%.

Electricity rates used were the current irrigation power rates (summer 2007) from Puget Sound Energy of 5.74 cents/KWH for consumption less than 20,000 kilowatt-hours (KWH) and 5.08 cents/KWH for consumption exceeding 20,000 KWH. In the most extreme case 38 kilowatts (kW) was demanded which is less than the 50 kW cutoff for a demand charge so no demand charges were applied. Diesel was assumed to cost $4.00/gallon and have 130,500 British thermal units (BTUs) of energy/gallon. It was assumed that 150 psi was required at the pump to adequately operate a big-gun system and that the application efficiency was 60%, while a boom required 50 psi at the pump and had an application efficiency of 85%. Because of a big-gun's lower efficiency more water must be pumped to meet the crops irrigation water needs. The results are given in Table 2.

Table 2. Comparison of typical annual energy costs for the big-gun and boom systems in Skagit and Whatcom Counties.

| | **Electric** | | **Diesel** | |
|---|---|---|---|---|
| | **Big-gun** | **Boom** | **Big-gun** | **Boom** |
| **Energy Cost per Season** | $ 2,585 | $ 723 | $ 13,014 | $ 3,396 |
| **Cost per acre-in** | $ 2.59 | $ 1.02 | $ 13.01 | $ 4.81 |
| **Reqd Motor Size (hp)** | 43 | 16 | 43 | 16 |

Running a boom system instead of a big-gun resulted in a total season energy savings (difference between the energy costs of big-gun and boom) of **$1,862** for an electric pumping plant, and **$9,618** for a diesel pumping plant.

Although a boom system has obvious pumping energy savings it can require more labor to move than a big gun and would therefore result in higher labor costs. If an additional 30 minutes per move (interviewed growers reported 15 minutes additional time required or less) is allocated for moving a boom system for 160 moves per season at a skilled labor rate of $15/hour, there will be an additional labor cost of **$1,200** per season in labor costs to move a boom compared to a big-gun.

If we further assume that energy rates will escalate at 11% per year (conservative estimate), that a grower could get a 10% return on otherwise saved money (unsecured investments), and that the boom system will last 15 years with no salvage value, then *the net present value of converting from a big-gun to a boom* (including energy, additional labor costs, and subtracting annualized equipment costs) is **$9,623** for an electric pumping plant and **$122,390** for a diesel pumping plant. This net present value of converting should be compared to the additional upfront cost of the cart to determine whether it is cost effective to convert. At the time of publication a new boom cart costs approximately $40,000. Since $122,390 is much larger than $40,000, in this scenario a grower using a diesel powered pump would save a significant amount of money over the life of the system by purchasing a boom cart and replacing their big-gun. A grower using an electrical pumping plant would not save money by converting, however.

These cost differences are the results of *only* energy savings. Things that were *not* considered that will also *have very real effects on the economics of converting from a big-gun to a boom type system are:*

- Return to the producer due to increased crop yields and quality that will result from better uniformity of booms (especially under windy conditions). Although very difficult to predict or quantify, these differences will likely have the greatest effect on a grower's bottom line.
- The differences in the purchase and maintenance costs of lower horse-power pumps needed for boom systems compared to big-guns. These differences will be significant. For comparison, the initial cost of a 6 cylinder diesel pump that will run two guns at 150 psi will be in the neighborhood of $28,000 while a 4 cylinder diesel pump to run two booms at 50 psi will be closer to $20,000.
- To compensate for poor uniformity additional water must be applied to adequately irrigate all areas of a field. This additional water and pumping costs were not included. These differences can be significant.

*All* of these unconsidered factors provide further (in addition to the energy cost differences calculated above) economic incentives to convert from big-gun carts to booms.

## Practical Considerations

- A big-gun nozzle is large enough to pass most debris moving in an irrigation line. However, boom system nozzles and pressure regulators have significantly smaller orifices and will plug with much smaller diameter debris. A filter will likely be needed if converting from a big-gun to a boom system, depending on how clean the source water is.

- High wind conditions appear to not only push an application pattern to one direction, but also to tighten it up as well. This means that under windy conditions growers can improve uniformity by decreasing the spacing between pulls. Unfortunately this will increase the number of "pulls" required to adequately irrigate a field. This is complicated by the fact that wind conditions often change over the course of a day.
- Despite any irrigation systems' inherent advantages and disadvantages, good irrigation scheduling and management have a large effect on energy cost savings and crop yield and quality.
- Proper pressure at the nozzles is important for uniform and efficient water application. Saving pumping energy costs by operating sprinklers at pressures below manufacturer recommendations can result in poor irrigation uniformity and poor yields, crop uniformity and crop quality. This may actually hurt a grower's bottom line.
- Maximizing the spacing between "pulls" is attractive because it decreases labor requirements, but irrigation uniformity and therefore crop yields and quality can suffer greatly.

## Conclusion

Under ideal conditions and optimal spacing, boom systems had similar distribution uniformity to big-gun systems. However big-guns were much more susceptible to poor uniformity in higher wind conditions and the overlap should be increased (fewer rows between pulls) under high wind conditions. In general, the uniformity of all the systems measured could be improved greatly by increasing the overlap. The application efficiency of the big-guns was about 60% compared to 85% for booms. This means that with a boom system, 42% more irrigation water makes it to the soil compared to a big gun. The lower pressures required by a boom and the water savings would likely make the transition to a boom system cost effective due to energy savings alone for those using diesel pumping plants. Those using electric pumping plants will likely see less economic benefits due to energy savings by converting. Although an irrigation system may have very real limitations, good management of existing systems is as important if not more important, to good crop uniformity and quality.