A Feasibility Analysis of Potato Production of a Bed System to a Row System Using Center Pivot Irrigation

By

John P Taberna Jr
M.S. Candidate (University of Idaho)
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This Paper was prepared for and presented to my Graduate Advisor Committee of:

Jeffrey C. Stark, PhD.
Professor and Chair, Crop Management. Research Professor, Agronomy, Chair of Horticultural Science Division. University of Idaho.

Stephen L. Love, PhD.
Extension Professional, Horticulture Superintendent, Aberdeen Research and Extension. University of Idaho.

Bradley A. King, PhD
Associate Research Professor, Aberdeen Research Experiment Station. University of Idaho.

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Project Summary

This project was undertaken in 2005 to determine whether bedded planting was a feasible alternative to the 36-inch row planting method commonly used in eastern Idaho. The primary emphasis of this work was on economic feasibility. From 2001 through 2005, the annual increases in potato production costs have kept ahead of the annual revenue generated through commodity prices and crop yields. Bedded planting may offer a new way of farming to help maintain profitability through increased yields and lower production costs per hundredweight (cwt). The main goal of this project is to increase tuber yield and reduce production cost per cwt of potatoes with the use of bedded planting.

Two potato planting methods were examined—one conventional, one new. The conventional method is the standard method of planting seed spaced at 12 inches within-row spacing in 36 inch rows (12x36). The new method of planting potatoes is 7 rows in a 144-inch bed, with within-row plant spacing at 18 inches and rows spaced at 18 inches (7R18x18). In comparison, the 12x36 method contains four rows across a 144-inch width. There are approximately 33% more plants (hills) per acre using the 7R18x18 method. The two fields chosen for study, located in Fort Hall, Idaho, were comparable in soil type and yield history.

The 12x36 method yielded 418 cwt per acre of payable potatoes. The 7R18x18 method produced 471 cwt per acre of payable potatoes. Based on samples sold through Wada Potatoes, Pingree, Idaho, the 7R18x18 method grossed $3,146.28 per acre on October 25, 2005 and $2,637.60 per acre on January 20, 2006. The 12x36 method grossed $2,867.48 and $2,562.34 per acre on the respective sale dates. Production costs were determined to be an additional $135.25 per acre for the 7R18x18 method as compared to the 12x36 method. Thus, the 7R18x18 method returned $143.55 per acre more than the 12x36 method in the October 25, 2005 sale. In contrast, the 7R18x18 method lost $59.99 per acre in the January 20, 2006 sale as compared to the 12x36 method. The loss was largely due to decreased prices for US #2 > 10 ounce, which was at $17.50 per cwt on October 25 and fell to $13.00 per cwt on January 20. The 7R18x18 method produced 56 cwt per acre of US #2 > 10 ounce, whereas the 12x36 method produced only 18 cwt per acre. The 7R18x18 method also produced 103 cwt of process grade potatoes and the 12x36 method produced only 66 cwt per acre. The 12x36 method produced more US #1's (77.2% vs. 64.7%) and greater tuber size of 7.5 ounce or above (40.6% vs. 32.9%) as compared to the 7R18x18 method.

Irrigation water was conserved with the bedding method. Total water applied from June 1 – September 1 was 18.92 acre-inches with the 12x36 method and 15.87 acre-inches with the 7R18x18 method, a savings of 3.05 acre-inches. Soil moisture data showed the 7R18x18 method had 'wetter' soil moisture, even when less water was applied. The 7R18x18 method likely used less power.

For the 7R18x18 method to become adopted as a common practice in potato production there must be an increased yield over conventional planting combined with power, water, fertilizer, and pesticide conservation per cwt. Some of these goals were achieved in the first year of testing and continued improvement will be achieved by refining agronomic practices.

Project Questions

Is the new Spudnik planter, planting at a 7R18x18 design on a bed width of 144 inches, economically feasible as compared to the standard practice of a 12x36 planting design on the same 144 inches? Will the 7R18x18 planting method conserve water, power, fertilizer, and maintain or increase yields?

The New Spudnik Bed-Planter

The Spudnik 7-row bed-planter uses the same hydraulic pump technology as other standard 6-row planters to dictate plant spacing. The efficiency is guided through radar-control-drives (RCD). The row units are spaced 36 inches apart in the common 6 row planter. In the new bed-planter (7R18x18), four of the row units are spaced at 36 inches, with three additional row units located in front (Figure 1). The additional three row units are spaced at 36 inches and off-set from the front four row units. This configuration produces rows spaced 18 inches apart. The uniqueness of the seven row planter's design is that it can also be used as a four to seven row planter (Figure 2). If four rows are desired, then the three front row units are switched off and only the four main row units are used. If five rows are desired, then the two outer row units of the front three are switched off. If six rows are desired, then the middle row unit of the front three will be switched off leaving the other six row units. If seven rows are desired then all seven row units are on. The distinctiveness of this design is that in the future this planter could be used with GPS and GIS mapping for variable rate planting. This is down-the-road; the planter must work first.

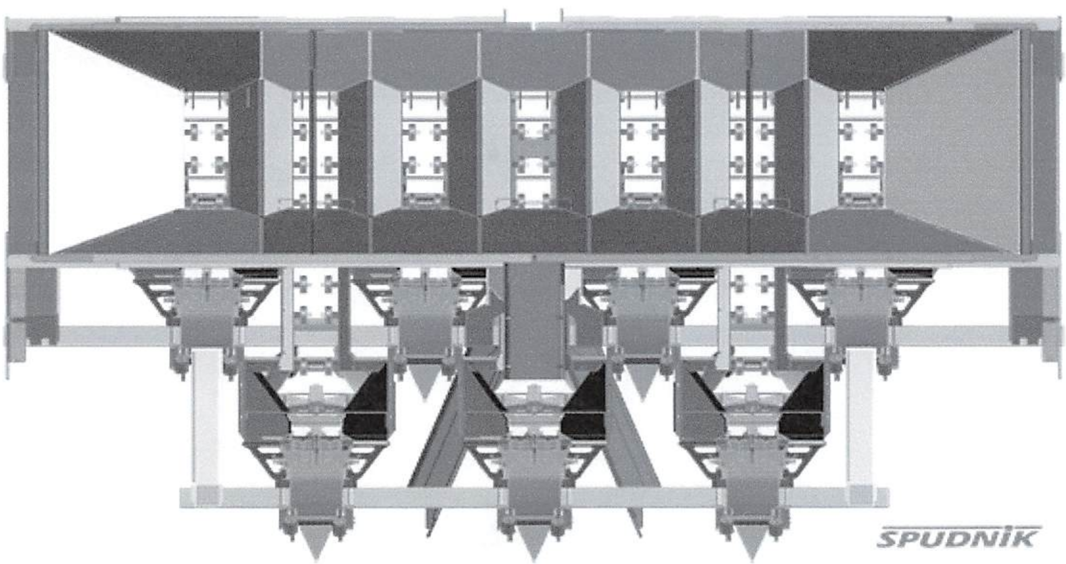


Figure 1. Top down view of the 7R18x18 planter.

Figure 2. The 7R18x18 planter can easily switch from 7 rows to 4 rows in the field.

~~Justification~~ The Situation

The future outlook for potato farmers in Idaho offers more pessimism than optimism, if the past is any predictor of the future. Using the linear regression formula $Y=A+Bx$, where Y=theme and x=year(s), the current potato farming scenario in Idaho can be quickly enumerated (Table 1). If the 1993 to 2004 yield trend continues, the state of Idaho yield average will reach 400 cwt per acre by the year 2018. However, the yield increase won't solve potato farmers' financial problems. By 2018, the cost of production will likely exceed $2,500 per acre. This will make the 'break-even' cost per cwt at over $6.00. Idaho has never averaged $6.00 returns for potatoes for three or more consecutive years. What is needed is a rapid reduction in acreage planted to potatoes combined with a larger yield increase, so that the cost of production is reduced per cwt.

Potato production in Bingham County, Idaho, followed the same yield and production trends as the state of Idaho. Using the linear regression models for 1993 to 2004 and 1990 to 2005, potato yields for Bingham County will also reach 400 cwt per acre for the first time around 2018. The average annual yield increase from 1990 to 2005 is approximately 3.2 cwt per acre per year. With an average price of $4.95 per cwt, this translates to an annual income increase to the grower of $15.84 per acre. The $15.84 per acre per year is hardly an inflation fighter. The increase in production costs from 2004 to

John this section; through page 8 is fascinating - However, it seems more than is needed to justify the research.

I suggest you keep the first paragraph on this page, keep figure 3, then write one more paragraph succinctly stating that farmers must improve returns to remain viable.

2005 was an estimated $129 an acre (Patterson). A new technology that can 'catapult' the current yield trend to a higher level where it exceeds current inflation is needed.

The gross revenue for potatoes produced in the state of Idaho has also declined from 1993 to 2004. If this trend continues, the linear regression indicates potato gross revenues will reach $594 million in 2018, down $228 million from its peak in 1995 at $822 million. The decline in gross revenue has occurred even though Idaho potato acreage has declined since the mid-1990's. In the mid-1990's, Idaho farmers planted a 'peak' acreage of some 420,000 acres to potatoes. In 2005, the potato acreage declined to around 360,000 acres. From the linear regression model, Idaho has experienced an acreage reduction of around 4500 acres per year since the mid-1990's. Yet this has not resulted in better potato prices. The potato prices received by farmers have not differed since the mid-1990's.

So the future trend in potato production, if left unabated, is fewer acres, higher yields, stagnant prices, and an overall lower net return for potatoes harvested in Idaho. The reduction in potato acreage in 2005 showed promise in higher potato prices. Most farmers were exceeding $8.00 per cwt through October 2005. However, these prices slipped to under $6.00 per cwt in early November and remained through February 2006. According to USDA statistical data, the 2005 crop is the lowest since 1989. In 1989, farmers received $10.00 per cwt and there were more acres in potatoes (1). Today, 40 million more people live in the USA since 1989. What's wrong? No wonder potato farmers are beginning to organize their marketing and production efforts through a national organization, United Fresh Potato Growers of America.

Table 1: Potato Production Trends in Idaho and Bingham County, Idaho.

Year-Range	Area	Theme (Y)	Linear Model
1993-2004	State of Idaho	Harvested Acre	$Y = 417.24x10^3 - 4.5629x$
1993-2004	State of Idaho	Yield	$Y = 328.95 + 2.7762x$
1993-2004	State of Idaho	Potato Price	$Y = \$4.95 - 0.0257x$
1993-2004	State of Idaho	Potato Value (million $)	$Y = \$680.36 - 6.1713x$
1993-2004	Bingham Co., ID	Yield	$Y = 302 + 4.1154x$
1990-2005	Bingham Co., ID	Yield	$Y = 308 + 3.16x$
1998-2005	Bingham Co., ID	Yield	$Y = 314.89 + 5.6071x$

Information sources: http://www.ag.uidaho.edu/aers/resources and http://www.nass.usda.gov.
Y= Theme; x= years.

Potato prices per cwt did not increase from 1990 to 2004. And when compared to prices received back in 1980, there still is no increase. Five year price averages received for all Idaho potatoes dropped from $5.06 per cwt in 1980-85 to $4.79 per cwt in 2000-04 (1). An interesting way to compare the potato prices over time is to compare the dollar value of potato prices from 1950 to 1999 based on the dollar value in 1983 (Figure 3) (2). The linear regression model showed a trend of $8.98 per cwt starting in 1950 and losing about 11 cents per cwt per year through 1999. Today, farmers are returning about $3.25 per cwt based on the dollar value in 1983.

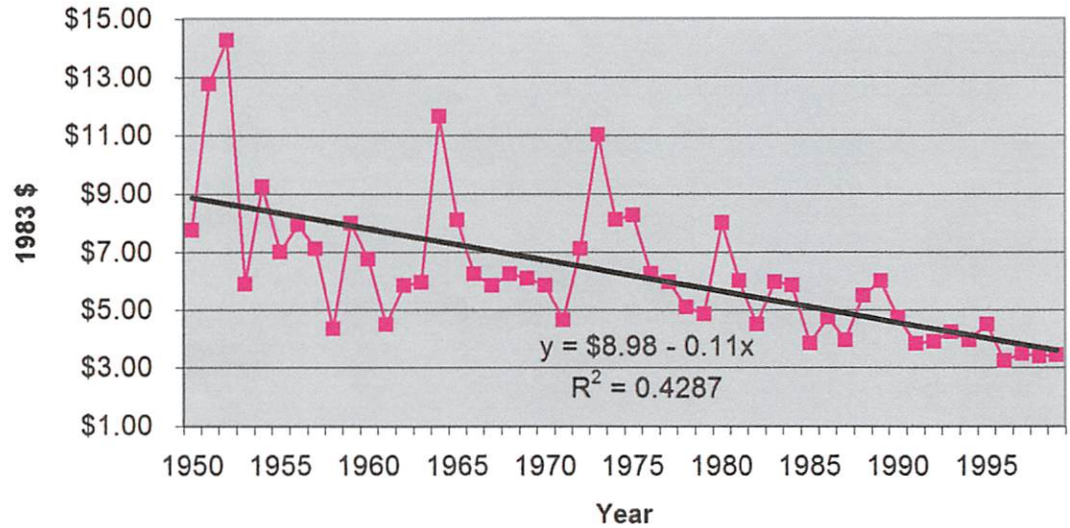


Figure 3. Potato prices from 1950 to 1999 based on the dollar value in 1983. Recreated from Potato Production Systems, Chapter 19, page 384.

In addition, the cost of production is increasing faster than gross revenue, even with the increased returns from higher yields. Dr. Paul Patterson, University of Idaho Agricultural Economist, provides accurate and realistic production costs for potatoes grown in several regions in Idaho (http://www.ag.uidaho.edu/aers). The production cost estimates include potatoes grown in different parts of the state with or without fumigation and storage. For potatoes raised in southeastern Idaho in 2005, Dr. Patterson estimated production costs at around $2026 per acre for fumigated and stored potatoes. This is an increase of $129 per acre over the 2004 production cost estimates. If potato prices average $7.00 per cwt in 2005-2006, a grower must produce an additional 18 cwt per acre just to cover the $129 per acre increase in production cost. For farmers receiving $5.50 per cwt, an additional 23 cwt is needed to cover inflationary cost alone. The average annual yield of 3.2 cwt per acre per year is not keeping pace with inflation.

There is no way the potato farming community can survive in Idaho if these trends continue into 2006 and beyond. According to Albert Wada at a United Fresh meeting, there were over 4,000 Idaho potato farmers in the 1970's. Today, there are fewer than 600 potato farmers and about 150 produce roughly 80% of Idaho's potatoes.

The year 2006 doesn't appear to look any better, financially. Estimates of increased fertilizer prices alone will add an additional $40 to $60 per acre. Diesel prices rose rapidly in the middle of the 2005 farming season, and will be much higher in 2006. Lease or land-rental prices for 'good' ground have also been competitive. There have been reports of several incidences where farmer's leases were due in 2005 and with competition from other farmers', they are now paying $100 an acre more per year on both their wheat and potato lease payments.

For 2006, it is likely that the cost of production for fumigated and stored potatoes in southeastern Idaho will exceed $2100 an acre. Breakeven yields will be 420 cwt per acre for $5.00 per cwt potatoes and 350 cwt per acre for $6.00 per cwt potatoes. This is troubling to potato producers in Bingham County, since the average payable yield from 2000 to 2005 is 349 cwt per acre.

As if financial concerns are not enough, farmers are also faced with water and power issues. A 'call-for-water' from water districts in Twin Falls and Elmore County has requested water from eastern Idaho. The city of Boise requested 300,000 acre-feet or more from the major potato growing areas of Idaho. This has led to potential lawsuits from what has now been designated as 'junior' and 'senior' water-rights. Legally, wells from 'junior' water-rights can be shut-off if necessary to fulfill another water demand in a drought stricken year. Power companies are also searching for more power units. There is a heavy demand in California and other areas for additional power. The power fee for California users is at least 13 times the rate Idaho farmers are currently being charged. Power fees in Idaho are rapidly increasing and will continue to do so. This has led to 'power' buyouts of farmers who are willing to limit their power use, or to not farm at all on a field and sell the power elsewhere.

The only way to break these trends is to become a 'trend breaker'. The United Fresh organization is trying to become a trend breaker by controlling acreage and production. The utilization of bedded planting versus row planting is potentially another trend breaker. Bedded planting allows farmers to utilize more of the land currently farmed, thereby reducing the cost per cwt produced. Bedded planting should allow farmers to reduce their acreage at a slightly faster rate; but slowly reduce their total production. For example, in a hypothetical but realistic situation, assume a farmer has 8 fields of 130-acres each that will be planted to potatoes. If his average yield is 375 cwt, then the gross production will be 390,000 cwt on his eight fields (1040 acres). Using a bedded planter, yields should increase a minimum 13% or 50 cwt per acre, since there are 33% more plants per acre ~~in the 7R18x18 system.~~ Using the bedded planter on 7 of his fields and not planting the other field would produce 386,750 cwt. This is a 12.5% reduction in acres and a mere 1% (3,250 cwt) reduction in gross yield. Not planting the 8th field could save $273,000 in potato production expenses ($2100 per acre x 130 acres).

Another advantage of using the 7R18x18 method in this hypothetical situation and not planting the 8th field is that it also reduces the cost of production per cwt. If the farmer plants all 8 fields (1040 acres) and yields 375 cwt per acre, or 390,000 cwt for the farm, at a cost of $2100 per acre, then his total cost of production is $2,184,000 for the 1040 acres and his resulting 'break-even' cost is $5.60 per cwt. Using the 7 row bed planter could cost an additional $132 an acre, primarily from increased seed, seed treatment and cutting costs. Based upon the $2100 per acre cost for the 12x36 method in 2006, it would likely cost the farmer $2232 per acre to use the 7R18x18 method. If the farmer only plants 7 of his fields (910 acres), then his production cost would be around $2,031,120. If the farmer only achieved an increase of 50 cwt per acre with the 7R18x18 method, then his total yield on the farm should reach 386,750 cwt. The 'break-even' cost under this scenario is $5.25 per cwt. This reduces the 'break-even' cost for the 7R18x18 method from $5.60 to $5.25 per cwt, a $0.35 per cwt savings. This is a dual savings to the grower. First, he saved $0.35 per cwt in 'break-even' cost. Second, he saved $273,000 by not planting his 8th field. With refined irrigation scheduling and agronomic techniques, this hypothetical scenario is likely to be achieved.

The adoption of bedded planting in Idaho makes economic sense. It allows the grower to make 'better' use of his ground. The cost of herbicides, fungicides, and other pesticides are the same on a per acre basis, regardless of planting methods. In actuality, herbicide costs for weed control may be reduced due to spraying on flat ground versus hills. Also, the bedded fields close rows quicker, thus providing shade to the ground which may reduce light availability to competing weeds.

Objections to bedded planting are the likelihood of increased incidences of white mold or water rot. This may or may not be true. Even if white mold and water rot increase, the bedded fields may only require the same amount of fungicides as many of the standard fields planted with the 12x36 method. Therefore, the end result could be less fungicide and herbicide applied per cwt of potatoes produced on bedded fields versus conventional fields.

Bedded planting is not new; it is practiced on a limited basis around the world, especially in parts of Europe, the United Kingdom, and with organic farmers when space is limited, or if water is in limited supply. The Standen Company in the United Kingdom manufactures and sells planters that vary from 2 to 8 rows, including their famous planter—the Goliath (Figures 4 and 5). (http://www.standen.co.uk/planter%20page.htm)

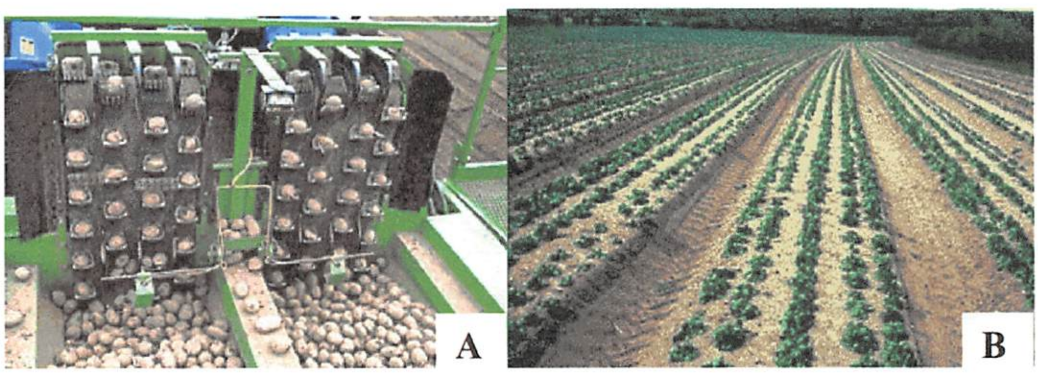


Figure 4. A) The Standen Company's 8-row planter. B) Beds from a 5-row bedded planter.

Figure 5. The Standen Company's famous 6-row planter named the Goliath.

The use of bedded planters in parts of Europe is employed mostly in dryland areas because of increased water utilization efficiency. According to an engineer from Spudnik (4), bedded planting is more efficient with water and fertilizer as compared to row planting. Farmers in Europe use bedded planting only in areas where rainfall is limited. In most of Europe, where rainfall is sufficient, farmers do not use bedded planting as there is almost always a risk of increased tuber-rot. There is an increased risk that the potatoes would even get harvested if the beds remained too wet in areas of 'high' rainfall. Most potato growing areas in Europe receive ample water; therefore, European potato farmers commonly use row plantings. This is probably where the row planting technology originated and was later transferred to the United States by European immigrants. In the early history of potato farming in the USA, most of the potato production was in higher rainfall areas such as New York, Maine, Pennsylvania, Vermont, Virginia, and the Carolinas. Row technology was used to prevent tuber-rot, in case heavy precipitation occurred late in the season. The furrow provided a drainage area. Today, though, much of the potato acreage has moved to the arid western states of Idaho, Washington, Colorado, and Oregon. In the arid west, is it necessary to use row technology that was designed primarily in higher rainfall areas? Could the West conserve water and power by switching from row technology to bedded technology?

The practice of bedded planting in eastern Idaho has been met with mostly failure, and farmers commonly abandon the bedded plantings due to increased problems associated with the narrow row technology. The main concerns or problems farmers have faced with bedded planting is smaller tuber size and often an increase in tuber rot (5). In 2005, only 3 to 4 farmers, beyond this study, used bedded technology and the use was primarily for seed production. There is one known commercial bedded field from a farmer in the Shelley, Idaho area where he uses bedded planting, successfully, for the production of red potatoes.

The concept of the 7 row bed planter makes sense in seed production and for commercially grown varieties where smaller tuber size is desired, such as red potatoes. The bed planting technology may not be a desirable option when larger tuber size is important, such as with Russet Burbank and Ranger Russet. The lack of tuber size due to bed planting is a common supposition most farmers have in not trying the technology. Row planting has had a long and successful history and most farmers see no real reason to change.

The new Spudnik bed planter may help farmers increase their profitability by increasing their yields and reducing their cost of production for growing potatoes per cwt produced. The bed planter may also aid in the conservation of power, water, fertilizer, and pesticides per cwt because the inputs are basically the same on an acre basis. This is a win-win situation for the farmer, farming community, and for environmental resources.

Potato Bed Design Comparison

The majority of potato producers in southeastern Idaho plant their potatoes with 36-inch rows and 12-inch within-row seed spacing (12x36). Currently, most harvesters, windrowers, sprayers, and other farm equipment are designed to straddle and operate around a 144-inch (12-foot) width. Today's modern harvester gathers 4 rows (12 feet) with usually one or two additional 4 rows windrowed onto the 4 row-area that the harvester picks-up. Thus, most harvester equipment will gather between 8-12 rows total. Both the harvester and windrower cover a width of 144 inches.

The new 7 row bed also has a width of 144 inches (Figures 6-7, p12). Thus, adapting to the 7R18x18 method from the traditional 12x36 method should require few adjustments. The major purchase is the planter itself, approximately $18,000 more than the standard 6-row planter. All of the other adaptations are mainly mechanical that can be switched from a 12x36 to the 7R18x18, and vice versa. The 7 row bed places three extra rows where the furrows were once located in the common 36-inch row system.

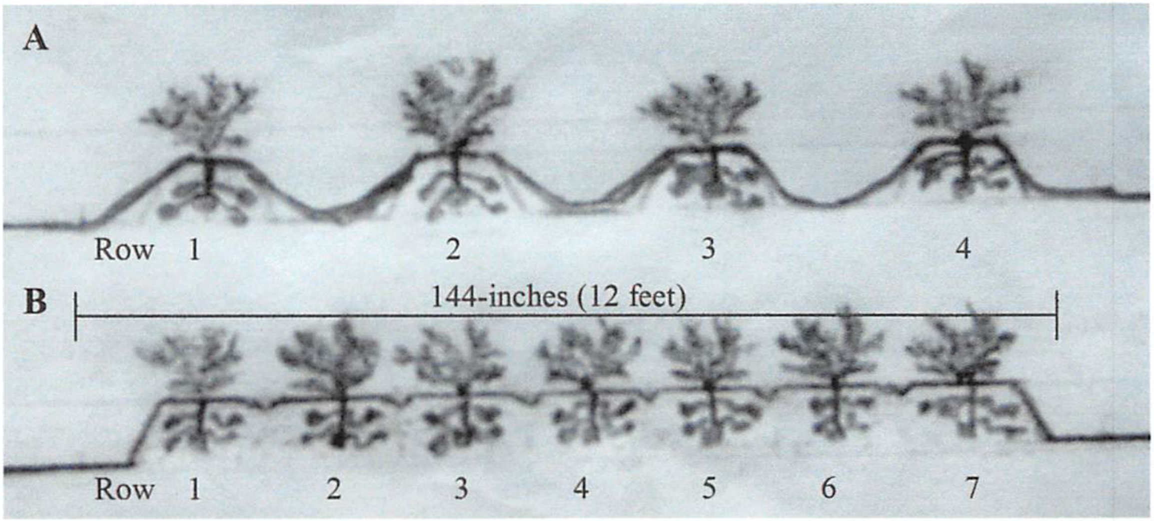


Figure 6. A) Hilling configuration in a field planted with a standard 12x36 planter. B) Hilling configuration in a field planted with a 7R18x18 planter. Rows 2, 4 and 6 in a bed planted with a 7R18x18 planter are located in the furrow space in a standard 12x36 potato-row cropping system.

Figure 7. Comparison of planting methods in field following vine kill. A) The standard 12x36 planting method. The two red flags mark the 4-rows or 144-inch wide area. B) The new 144-inch bed, 7R18x18 planting method.

Plant Density

With the standard 12x36 planting, there are 14,520 plants, or hills, per acre. Using the 7R18x18 planter, the plant density increases to 19,360 plants per acre. This is a 33% increase in plants on the same acre of land. To reach this density with a 12x36 planter, plant spacing would require adjusting from 12 inches to 9.2 inches, which is already practiced by seed growers. Farmers that use the new Spudnik planter are not stuck with an 18x18 design. The 18-inch rows are fixed, but plant spacing is not. Farmers can actually plant as close as 6-inches (6x18) in-row, producing 58,080 plants per acre, or as far apart as 30-inches (30x18) in-row, producing 11,600 plants per acre.

Spatial Dynamics

The 7R18x18 planting is a diagonal planting method where plants are spaced 18-inches apart in a diamond-shaped pattern. There are more plants per acre with more spatial area for the tubers to grow in. While it may seem impossible to provide more growing space when the row width is cut from 36 inches to 18 inches, this is achieved by eliminating the area covered by the furrow in the standard 12x36 system.

The standard 36-inch row does have a growth barrier for tubers and most rooting systems—the furrow. Depending on the situation, the furrow has advantages or disadvantages. The furrow is an excellent area for drainage. During over-irrigation or excessive rainfall, it can prevent serious tuber rotting. The furrow collects most of the water, allowing the hill to dry quickly. This is not so with bedded planting. When the beds get too wet, serious problems can arise quickly. This is especially true of white mold and of the water molds such as pink rot. So the furrow area does have value in certain situations.

The growing area of an individual plant is most likely the radius of the distance of its nearest neighbor, plus the volume it occupies down to 12 –16 inches. This can be best demonstrated by the formula measuring the volume of a sphere, $\pi r^2 d$. A plant spacing of 12-inches produces a 6-inch radius for each plant. Any further than 6-inches would interfere with the growing area of its neighboring plant; such as what happens when there are doubles and triples due to planter performance mishaps. Thus the total growing area, assuming a 12 inch depth, of an individual plant using the 12x36 method is 1356 in^3 [$\pi \times 6^2 \times 12$]. For the 7R18x18, plants are spaced 18x18 inches apart, so the growing area per individual plant is 3052 in^3 ($\pi \times 9^2 \times 12$). So there is 2.25 times the growing area per plant using the 7R18x18 method than the 12x36 method even though there are 33% more plants or hills per acre. It could be argued successfully that the lower side-hill and furrow area has some growing area merit for the plant using the 12x36. Considering this argument, then the 7R18x18 method still has close to twice the growing area as does the 12x36 method. Therefore, spatial area should not be a limiting factor in achieving tuber size and total yield.

Now, a larger growing area does not mean higher yields. In fact, in the 12x36 system a skip or a 14 to-16-inch spacing actually produces lower yields as compared to the 12-inch spacing (6). Therefore, the 18x18 spacing may actually produce lower yields per plant. It is unlikely that the yield loss per plant would be 33%. A more likely figure would be 10% or less. However, further research is necessary to verify the potential yield loss per plant on an 18-inch plant-spacing scale. Nonetheless, until further research is done, a more likely yield increase from the 7R18x18 method is 20 to 25% as compared to the conventional 12x36 method.

We measured rooting mass and rooting distribution indirectly, or qualitatively, through volumetric soil moisture content using a portable TDR soil moisture meter. After an irrigation event, we hypothesized, that the 'drier' areas had more root density than the 'wetter' areas. This indirect way of measuring root density has some merit in that almost all of our soil-water measurements that were 4-inches from the plant were consistently

John - not true, because of phototropy plants will seek areas where they can get sufficient light. If their growing space is, irregular, the expand into the open areas. The one advantage grid planting may give is a longer early growth period without competition. It may also allow for better early light interception / unit area the driest parts of the bed. The soil moisture measurements furthest from any plant were the 'wettest' readings of the bed. Our measurements were done 1 day following an irrigation event of 0.75 inches on a loamy sand soil. We found the rooting- mass and-distribution more evenly distributed in the 7R18x18 bedded field situation as compared to the hilling dynamics of the standard 12x36. In the 12x36, the hill accounted for at least 75% of all rooting-mass and-distribution (Figure 8). The side-hill probably accounted for around 20% of the rooting-mass and-distribution. The furrow harbors another 5% of the entire rooting-mass and-distribution. The furrow area is easier to get wet (85% + ASM) and remain wet during the majority of the irrigation season; with very little drying below 85% ASM throughout the irrigation season.

Figure 8. The rooting area of a standard hill-bed using the 12x36 method. The photo was downloaded via the internet; source unknown.

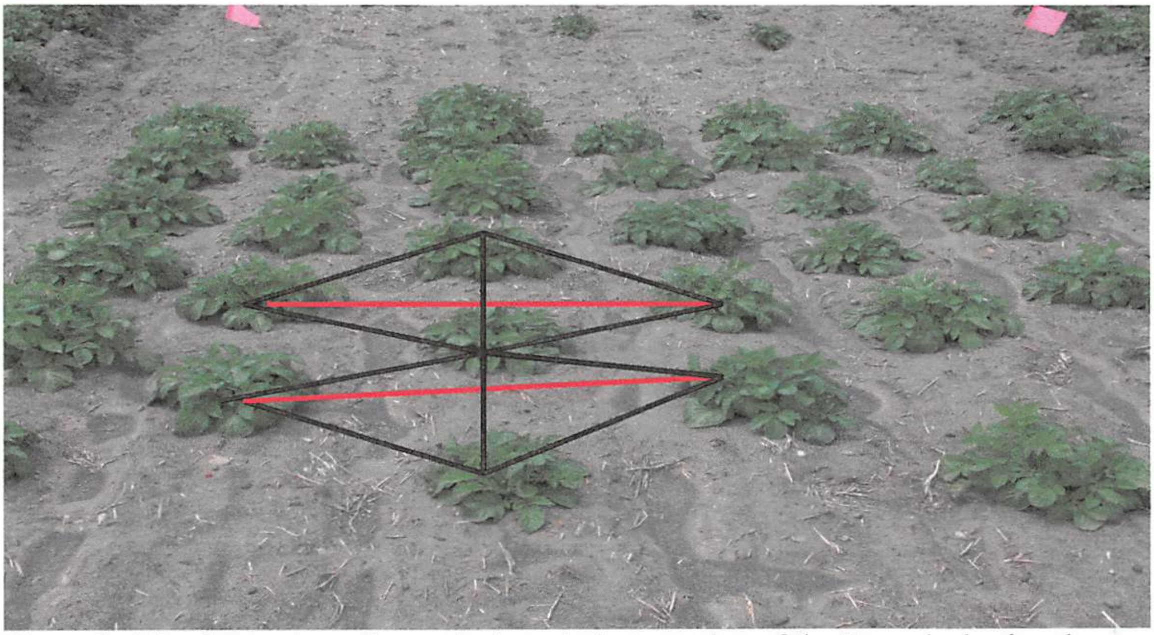


Figure 9. The diagonal, or diamond, shaped plant-spacing of the 7-row bed using the 7R18x18 planter. The flat area of the bed without the furrows and the 18x18 diamond shape allow for a more even distribution of root density as compared to the standard hill using the 12x36. Red lines = 36-inches; Black lines = 18-inches.

Additional costs with the 7R18x18 method

Approximately 7 cwt per acre of additional seed are required using the 7R18x18 method. At $9.00 per cwt for seed and $1.75 per cwt for cutting and treating the seed, this equals an additional $75.25 per acre for seed cost. It is also likely that an addition $45 per acre will be spent on fungicides and fertilizer. One additional fungicide for white-mold suppression plus additional micronutrients will cover the estimated $45. This is only a guess, further research will verify if additional fertilizer and fungicide over conventional rates are needed. Finally, it will cost at least $15 per acre in purchasing and maintenance expenses for the Spudnik bed planter, as compared to the 6-row planter. Thus, the minimum total additional cost for owning and operating the Spudnik bed planter is an estimated $135.25 per acre.

Planting

Planting with the bedded planter is slightly different from the row planter. Pre-marking is not necessary with the bedded planter. The ground is prepared as normal, and then the field can be planted with the bedded planter as shown in Figures 10 - 11. Consequently, there is a one-pass savings of fuel and tractor use when using the bedded planter as compared to row planting.

Figure 10. Planting with the Spudnik bedded planter. The ground is prepared as normal but no pre-marker is necessary. After ground preparation, the bed planter is ready.

Dammer diking and cultivation

There is no post-planting cultivation used with the bedded system. A modified dammer diker was used on the project field where two 'normal' dike paddles were used on the outside of the 144-inch bed and with 'rubber-like' smaller dikes, imported from the United Kingdom via Spudnik, that are spaced 18-inches apart and used in-between rows of the bed.

Figure 11. The modified Dammer Diker for a bed system. The outside paddles are 'normal', the inside paddles are used for a 'smaller' insertion into soil.

Harvesting

Only one windrower, instead of two, is needed with the bed planting system. This is mostly due to the increased yield per unit area. With the 12x36 method, two windrowers are used, thus 12 rows are picked up by the 'four-row' harvester. With the 7 row bedded planter, 7 rows are windrowed on top of the other 7 rows on the 144-inch bed where the harvester picks up 14 rows. Adding another windrower to the 7 row bed would be 21 rows which would be too many potatoes to harvest without doing additional harvester modifications.

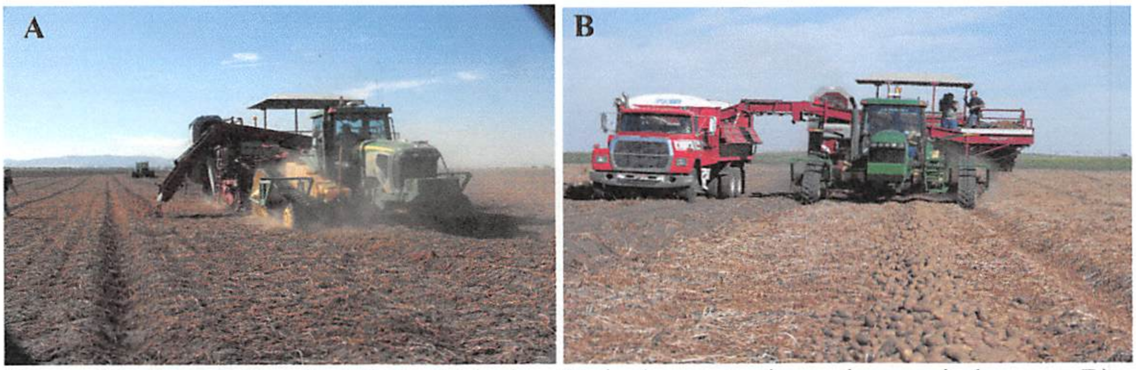


Figure 12. Harvesting the 7R18x18 bed. A) The harvester is used as a windrower. B) The beds at harvest.

Project Goals and Objectives

The goal of this project was to determine whether the 7R18x18 planting method is a viable alternative to the current 36 inch row planting method. Potatoes grown in a field planted with the new Spudnik planter were compared to potatoes in a nearby and similar field planted with the standard practice.

The specific objectives of this study were to determine if the 7R18x18 planting method resulted in:

- higher yields,
- greater economic returns,
- reduced power use per hundredweight (cwt) of potatoes,
- reduced fertilizer use per cwt of potatoes,
- reduced pesticide costs per cwt of potatoes, and
- better water utilization and conservation.

John: Somewhere, maybe around pages 12-13, you need a comprehensive literature review on previously conducted spatial studies with potatoes. Bill Bohl recently did a search on this topic and you may be able to use his information to complete this task.

Project Methods

Field selection

Two nearby fields separated by a ½ mile were selected for comparing the two different planting methods. The 7R18x18 bedded field was planted beginning on April 26, 2005. The other field was planted with the standard 12x36 method starting on May 1, 2005. The cultivar Russet Burbank was used for both fields. The seeding rate for the 12x36 method and the 7R18x18 method was 18.6 cwt and 24.5 cwt per acre, respectively. Both fields are loamy sands, with historic payable tuber yields of 375 cwt or more. The 12x36 field was 156 acres. The 7R18x18 was 170 acres. The field's wells are 80-100 feet deep. Both fields were managed by Cedar Farms, Inc. (Todd Jensen, farm manager; Albert Wada, owner). Neither study field was fumigated.

Soil characteristics

Soil on both fields consists of variants and inclusions of the soil series Sheepskin-Magallon-Bartonflat and Kukvey. As identified by the 1994 NRCS soil survey of Fort Hall, these soils are a mix of loamy sand and gravelly, loamy sand. Available water holding capacity varies from 0.05 to 0.09 in/in. Soil pH varies from 6.6 to 7.8, but typically has a pH around 7.0. Water permeability is 6 to 20 inches per hour. Soil particle separates using the hydrometer method typically range from % Sand at 77 ± 10, % Silt at 17 ± 4, and % Clay at 6 ± 6.

Climate

The following climatic information was downloaded from an AgriMet weather station located approximately ½ mile between the two fields on the Fort Hall Indian Reservation. The AgriMet data between 1996 and 2004 was downloaded at the website (http://www.usbr.gov/pn/agrimet/). The abbreviation FTHI denotes this weather station is located at Fort Hall, Idaho.

The frost-free growing season averages 125 days; typically between May 10 and September 15. The mean daily temperatures for the months from April through September are the following: April—45 F; May—54 F; June—61 F; July—69 F; August—69 F; September—59 F. The annual precipitation varies between 8 to 12 inches. From 1996 to 2004, average precipitation in May and June was 1.60 inches. In 2005, it was 4.54 inches.

The average heat-units or growing degree-days (GDDs) in Fort Hall between April 1 and September 1, 1996 through 2004 was approximately 1720 GDDs (50 F base; 85 F max). For comparison, Parma, Idaho averaged approximately 2700 GDDs and Hermiston, Oregon averaged around 2400 GDDs during the same time period. For Fort Hall in 2005, the GDDs were 1558.

Irrigation and soil moisture measurements

All irrigation and rain events were recorded in Cedar Farms' irrigation log book. A nearby AgriMet weather station was used for ET's and for accurate rainfall measurements. At the beginning of the growing season, soil moisture measurements were collected using T-Tape International's, San Diego, California, telemetry soil moisture data-logger which operated on frequency domain reflectometry (FDR). This had great advantage over other soil moisture instruments in that all soil moisture measurements were recorded and logged on a 15-minute cycle throughout the 24-hour daily time period. No field help was needed to obtain soil moisture readings. The data were easily accessible via the internet using a personal access code and password (http://www.cropsense.com). T-Tape sells drip irrigation systems (http://www.t-tape.com) and uses their telemetry FDR system for monitoring soil moisture in drip irrigation systems. They offered their technology free-of-charge and installed the units in late May and early June. We used a portable TDR meter as a back-up and provided the data to the farm manager for irrigation scheduling. Unfortunately, the T-Tape soil moisture systems did not perform as accurately as hoped. Only one of the sensors had reliable data and the others did not work well at all (see examples in end of report). The only data we had for soil moisture in the month of June was from the portable TDR readings. We needed soil moisture sensors in fixed locations as to reduce the variability associated with portable probes. After realizing that the T-Tape sensors were not going to provide the accurate data needed, TDR sensors from Campbell Scientific, Logan, Utah were placed at fixed locations and were read on a regular basis starting July 9. In the results, we separated soil moisture readings by June 1 to July 8 (portable TDR) and from July 9 to August 17 (stationary TDR). This way, soil moisture readings via the portable TDR probes were kept separate from the stationary TDR readings.

In addition to Cedar Farms irrigation log-book, we kept separate irrigation records with rain gauges and separate soil moisture records using TDR at fixed locations in both the 12x36 field and 7R18x18 field from July 9th to August 17th. In the 12x36 field, a sensor was placed in the top of the hill (Figure 15, p23). The top of the hill represents about where at least 70% of the entire rooting mass is located (Figure 8, p14). This is also where most farmers dig with their shovel for estimating soil moisture and irrigation needs. Another sensor was placed in the lower side-hill, approximately 4-6 inches above the furrow. This area represents about 25% of the rooting mass and usually remains moderately wetter as compared to the top-hill. Farmers may often check the side-hill area, but will irrigate if the top-hill area is drier. The final sensor was placed in the furrow. The furrow represents about 5% of the rooting mass and usually is wet throughout the irrigation season. Farmers rarely check the furrow for irrigation scheduling; unless out of curiosity.

The bed system is flat with no furrows, except on the outsides. The bedded field was planted east to west, thereby one furrow was a south-wall and the other furrow was located as a north-wall. Station-1 was located between rows 1 and 2; row 1 was closest to the south-wall of the furrow (Figure 6, p12). The TDR in Station-2 was positioned between rows 4 and 5, which was at the center of the bed (Figure 6, p12). Station-3 was positioned between rows 6 and 7; row 7 was closest to the north-wall of the other furrow (Figure 6, p12). The compared results of the top-hill TDR, where farmers dig the most with their shovel for ASM estimation, and the average TDR readings across the bed are shown in (Figure 15, p23). The separate readings of stations 1, 2, and 3 are shown in (Figure 13, p23). The variability of soil moisture in the row system is shown in (Figure 14, p23).

Tuber yield, tuber quality, and economic assessments

Cedar Farms harvested both fields in late September and the potatoes were transported to their assigned cellars. Potatoes were sorted going into the cellar where the process grade was sold to a local processor in Blackfoot, Idaho. Tuber quality data was collected at harvest. Sub-samples were pulled from each truckload and graded at Wada Potatoes in Pingree, Idaho. Yield estimates were done from cellar measurements by the Wada Potato organization and also independently by their insurance company.

Economic returns were estimated by running the sub-samples based on two sale dates, October 25th and January 20th. Potato prices per cwt are listed in Table 2. The warehouse charged $5.17 per cwt to sort, box, package, and sell the potatoes.

Table 2: Potato prices per grade on October 25, 2005 and January 20, 2006.

Grade	October 25, 2005	January 20, 2006
#2s 6 oz.	$13.00	$9.00
#2s 10 oz.	$17.50	$13.00
Process	$2.17	$2.17
4-7.5 oz.	$12.31	$11.50
100 ct	$14.50	$15.00
90 ct	$16.00	$16.00
80 ct	$17.00	$16.00
70 ct	$18.00	$16.50
Bakers	$16.18	$16.00

Nutrient management

Fertilizer was recommended based on a 450 cwt per acre yield goal on the 12x36 and a 600 cwt per acre yield goal on the 7R18x18. Petioles were pulled from tuber initiation until about 3 weeks prior to vine-killing to aid in in-season fertilizing. There was a total 368 lb N per acre applied on the 7R18x18 field and a total 323 lb N for the 12x36 field.

Other fields planted with the Spudnik bed planter

There were 9 fields planted with the Spudnik bed planter in 2005. Only one of the fields was nearby a conventional field of similar yield and soil type so it was the only one included in this study. The other 8 fields were separated by considerable distance and the nearest conventional field(s) to them were of different soil types so they were not included in this study. However, a summary of the performance of the other 8 fields is included in the discussions.

Tuber Yields, Tuber Quality, and Economic Returns

Table 3: Dockside inspection and potato yields and quality from Wada Potatoes
Dockside Return and Worksheet 25-Oct-05

Per Dockside Inspection:	Percentages		Cwt per Acre	
	12x36	*7R18x18*	*12x36*	*7R18x18*
Net Yield	418	471	418	471
Packout	84.2%	78.2%	352.0	368.3
US #1s	77.2%	64.7%	322.7	304.7
#2s 6 oz.	2.7%	1.5%	11.3	7.1
#2s 10 oz.	4.3%	12.0%	18.0	56.5
Process	15.8%	21.8%	66.0	102.7
Total	100%	100%	418	471
%Size of #1's	40.6	32.9	131.0	100.2

Table 4: Potato yields, quality, and economic returns from October 25, 2005 sale.

Planting Method	Gross Yield (cwt/acre)	Tare[1] (%)	Net Yield (cwt/acre)	US #1 (%)	7.5 oz + (%)	Gross Return ($/cwt)	Gross[2] Return ($/acre)
12 x 36	481.5	15.2	418	77.2	40.6	6.86	2867.48
7R18x18	532.7	13.1	471	64.7	32.9	6.68	3146.28

[1]Percent of gross yield that was unusable due to dirt, vines, rot or green potatoes.
[2]Return after subtraction of USDA grading process and Idaho Potato Commission fees.

Table 5: Potato yields, quality, and economic returns from January 20, 2006 sale.

Planting Method	Gross Yield (cwt/acre)	Tare[1] (%)	Net Yield (cwt/acre)	US #1 (%)	7.5 oz + (%)	Gross Return ($/cwt)	Gross[2] Return ($/acre)
12 x 36	481.5	15.2	418	77.2	40.6	6.13	2562.34
7R18x18	532.7	13.1	471	64.7	32.9	5.60	2637.60

[1]Percent of gross yield that was unusable due to dirt, vines, rot or green potatoes.
[2]Return after subtraction of USDA grading process and Idaho Potato Commission fees.

Table 6: Carton profile of US #1's produced and the number of 50 lb boxes per acre

Planting Method	Total Boxes of 7.5 oz +	Number of boxes 100 ct	Number of boxes 90 ct	Number of boxes 80 ct	Number of boxes 70 ct	Number of boxes Bakers	Number of 50 lb bag Non-A's
12 x 36	262	86	78	60	22	16	384
7R18x18	200	52	44	42	50	12	410

Table 7: The economic returns of potato sales on a per acre basis.

Planting Method	Sales on 10-25-05	Sales on 1-20-06	Production Cost	$Returns on 10-25-05	$Returns on 1-20-06
12x36	$2867.48	$2562.34	$2026.00	$841.48	$536.34
7R18x18	$3146.28	$2637.60	$2161.25	$985.03	$476.35
		7R18x18	Difference:	+$143.55	-$59.99

Table 8: Soil moisture data using TDR and irrigation on the 7R18x18 and 12x36 fields.

Moisture Monitoring--7-Bed Rows versus Standard 36" Rows

TDR Flags ASM100%.= 16.0

ASM65%= 10.0

12x36

Date	Top (Sites)	Side (Sites)	Furrow (Sites)	Average	SD	CV		Rain Gauges 1	2	3	4	Average	SD	CV
9-Jul	11.8	16.8	22.8	17.1	5.51	32%								
12-Jul	17.9	24.8	28.6	23.8	5.42	23%		1.00	0.90	0.95	1.00	0.96	0.048	5%
14-Jul	14.1	21.7	27.4	21.1	6.67	32%		0.75	0.75	0.75	0.75	0.75	0.000	0%
15-Jul	12.5	20.0	24.6	19.0	6.11	32%								
18-Jul	12.1	19.3	24.2	18.5	6.09	33%		0.75	0.75	0.80	0.75	0.76	0.025	3%
19-Jul	11.7	19.5	24.6	18.6	6.50	35%		0.75	0.75	0.75	0.75	0.75	0.000	0%
21-Jul	11.9	22.9	28.1	21.0	8.27	39%		1.35	1.35	1.25	1.30	1.31	0.048	4%
24-Jul	12.8	19.9	24.5	19.1	5.89	31%		0.80	0.80	0.90	0.85	0.84	0.048	6%
25-Jul	12.0	18.6	23.3	18.0	5.68	32%								
25-Jul	12.8	19.1	26.1	19.3	6.65	34%		0.65	0.65	0.65	0.70	0.66	0.025	4%
27-Jul	10.1	15.8	21.9	15.9	5.90	37%								
28-Jul	10.2	16.6	24.6	17.1	7.21	42%		0.40	0.35	0.30	0.30	0.34	0.048	14%
30-Jul	9.8	16.7	24.1	16.9	7.15	42%		0.40	0.40	0.45	0.50	0.44	0.048	11%
31-Jul	13.7	21.7	28.2	21.2	7.26	34%		0.90	0.90	0.75	0.80	0.84	0.075	9%
2-Aug	11.7	17.6	25.4	18.2	6.87	38%		0.40	0.40	0.30	0.30	0.35	0.058	16%
3-Aug	10.7	16.4	23.3	16.8	6.31	38%								
4-Aug	9.9	15.0	21.8	15.6	5.97	38%								
6-Aug	11.3	15.4	27.1	17.9	8.20	46%		0.90	0.90	0.95	0.95	0.93	0.029	3%
7-Aug	10.8	15.0	23.9	16.6	6.69	40%								
10-Aug	15.1	14.6	23.4	17.7	4.94	28%		0.60	0.60	0.55	0.55	0.58	0.029	5%
11-Aug	14.2	15.0	23.9	17.7	5.38	30%		0.40	0.40	0.40	0.40	0.40	0.000	0%
13-Aug	11.5	14.3	21.3	15.7	5.05	32%								
17-Aug	13.6	14.3	21.8	16.6	4.55	27%		0.55	0.60	0.55	0.60	0.58	0.029	5%
Average:	12.3	17.9	24.6	18.2	6.3	34.6%	Total Irrig:	10.6	10.5	10.3	10.5			
SD:	1.9	3.0	2.1											
CV:	15%	17%	9%											

Total Water 10.5

7R18x18

Date	1 (Sites)	2 (Sites)	3 (Sites)	Average	SD	CV		Rain Gauges 1	2	3	4	Average	SD	CV
9-Jul	12.4	14.0	14.2	13.5	0.99	7%								
12-Jul	16.0	15.0	16.0	15.7	0.58	4%		1.00	0.95	1.00	0.95	0.98	0.029	3%
14-Jul	16.4	14.7	15.7	15.6	0.85	5%		0.75	0.75	0.75	0.75	0.75	0.000	0%
15-Jul	13.6	13.5	14.2	13.8	0.38	3%								
18-Jul	14.0	13.0	12.5	13.2	0.76	6%		0.80	0.90	0.85	0.80	0.84	0.048	6%
19-Jul	15.1	13.6	14.0	14.2	0.78	5%		0.65	0.65	0.65	0.65	0.65	0.000	0%
21-Jul	8.7	10.6	11.1	10.1	1.27	12%								
24-Jul	8.8	11.4	11.2	10.5	1.45	14%		0.75	0.75	0.75	0.85	0.78	0.050	6%
24-Jul	13.9	14.5	13.5	14.0	0.50	4%		0.85	0.80	0.80	0.75	0.80	0.041	5%
25-Jul	14.3	15.0	14.7	14.7	0.35	2%								
27-Jul	9.0	11.7	11.2	10.6	1.44	14%								
28-Jul	8.5	11.5	10.7	10.2	1.55	15%								
30-Jul	9.5	13.0	11.5	11.3	1.76	15%		0.75	0.75	0.75	0.75	0.75	0.000	0%
31-Jul	10.1	13.6	11.9	11.9	1.75	15%		0.25	0.25	0.25	0.25	0.25	0.000	0%
2-Aug	13.0	16.2	14.7	14.6	1.60	11%		0.60	0.60	0.65	0.60	0.61	0.025	4%
3-Aug	10.7	14.7	13.2	12.9	2.02	16%								
4-Aug	9.2	13.2	11.7	11.4	2.02	18%								
6-Aug	11.1	15.0	12.9	13.0	1.95	15%		0.70	0.70	0.70	0.70	0.70	0.000	0%
7-Aug	9.2	13.8	11.7	11.6	2.30	20%								
10-Aug	9.1	14.0	11.8	11.6	2.45	21%		0.70	0.70	0.70	0.65	0.69	0.025	4%
11-Aug	8.3	12.8	10.3	10.5	2.25	22%								
13-Aug	10.1	14.5	12.3	12.3	2.20	18%		0.60	0.60	0.65	0.60	0.61	0.025	4%
17-Aug	12.8	16.4	13.8	14.3	1.86	13%		0.65	0.60	0.60	0.60	0.61	0.025	4%
Average:	11.5	13.7	12.8	12.7	1.4	11.9%	Total Irrig:	9.1	9.0	9.1	8.9			
SD:	2.6	1.5	1.6											
CV:	23%	11%	13%											

Total Water: 9.0

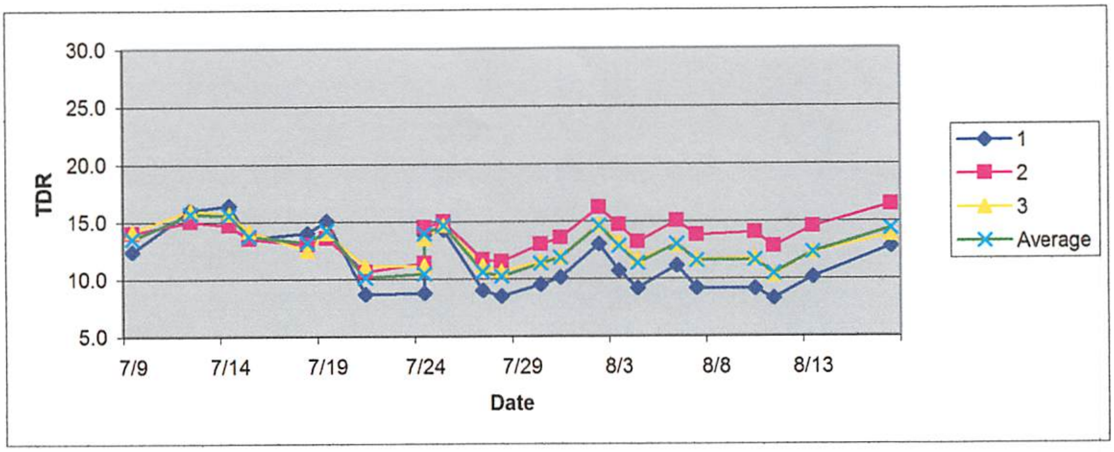


Figure 13. The soil moisture distribution of the 7R18x18 across the bed.

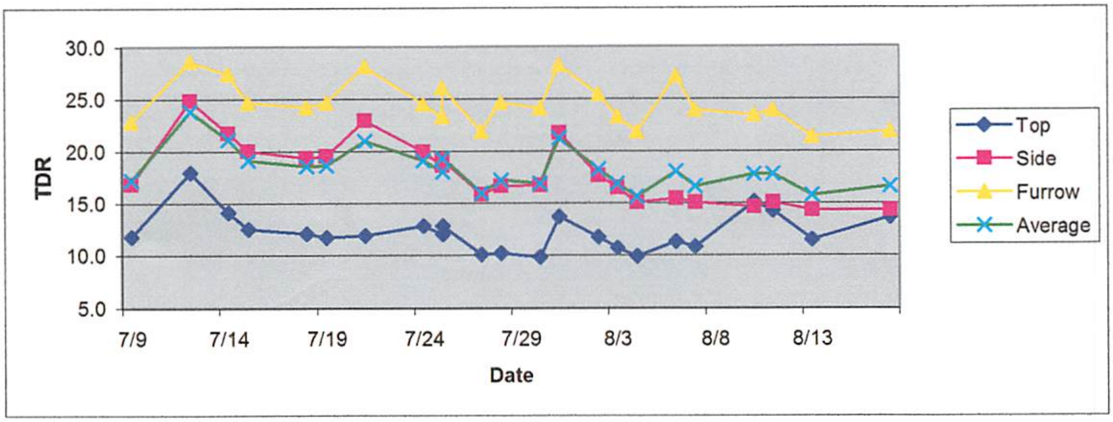


Figure 14. The soil moisture distribution in the 12x36 field. TDR sensors were placed in the top-hill, side-hill, and furrow.

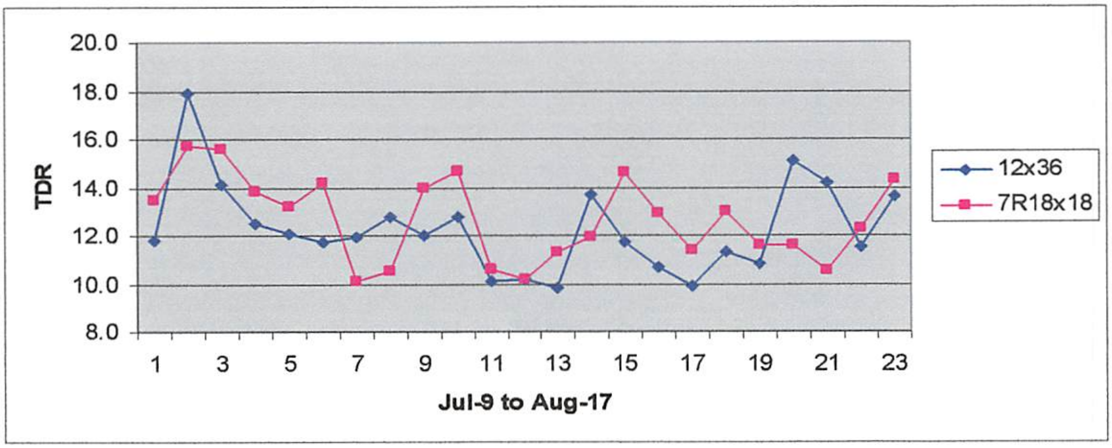


Figure 15. The soil moisture content comparison between the 12x36 and the 7R18x18 planting methods. The 12x36 field TDR measurements were in the main root zone area only. The TDR readings in the bedded field were averaged across the bed.

Discussion

Tuber yield, tuber quality, and economic returns (Tables 3-7, p21.)

The income a farmer receives for a potato crop is dependent largely upon the yield, tuber size distribution, overall quality, and the current market price. Tables 3-7 report the yields, US #1's, distribution of potato size, and the economic returns.

Net yield was highest on the 7R18x18 at 471 cwt per acre and lower on the 12x36 at 418 cwt per acre. This was 53 cwt per acre higher yield, or 12.5% more yield, for the 7R18x18 method. This was less than expected. We expected a 20-25% yield advantage using the 7R18x18. This assumption was derived because there are 33% more plants with ample spatial area for the plants and tubers to grow in. The lack of production was probably due mostly to agronomic errors. The amount of water and fertilizer required in a bedded field may have been overestimated. The University of Idaho nutrient guidelines for a 600 cwt yield goal with a 5 ppm soil-N test is 300 lb per acre of fertilizer N plus an additional 45 N for straw decomposition; thus around 345 lb N total (7). The bedded field received 368 lb N per acre. This may have been too much and the bedded field did not come close to the 600 cwt yield goal. The 600 cwt goal was based on the premise that the field had a 475 cwt yield before. The yield goal for the 7R18x18 method should likely be based on proven yields from an average of the three previous crops plus a factor multiplied by 1.25. For instance, if this field had a three year yield average of 410 cwt per acre, then the yield goal would have been around 513 cwt (410 cwt x 1.25). Based on University of Idaho fertilizer guidelines, the 500-513 cwt yield goal would have required around 305 lb N per acre.

The 305 lb N fertilizer rate may have helped the 7R18x18 achieve a lower yield of process and US #2 grade potatoes (Table 3). The combined US #2 yield for the 7R18x18 method was 63.6 cwt (6 oz + 10 oz) and for the 12x36 was 29.3 cwt. Therefore, the 7R18x18 method produced 34.3 cwt per acre more of US #2's. Financially, this helped the 7R18x18 method on the October 25 sale as the US #2 market was just as good as the carton market (Table 2, p20). However, due to the slip in US #2 prices, which is common, the economic returns were less for the 7R18x18 method on January 20 (Table 7, p21). The 7R18x18 method produced 102.7 cwt per acre of process grade potatoes, while the 12x36 method produced 66.0 cwt per acre. This was an additional 36.7 cwt of process potatoes for the 7R18x18 method. Adding the total US #2 with the total process grade potatoes, the 7R18x18 method had 71 cwt per acre more than the 12x36 method. Unfortunately, the entire 53 cwt per acre yield advantage of the 7R18x18 method over the 12x36 method came from the US #2 and process grade potatoes. The over application of fertilizer N had most likely contributed to an elevated yield of process and US# 2 potatoes.

Discuss differences in size distribution its impact on profits and its relationship to plant density

The 12x36 method produced more US #1s (77.2% v. 64.7%) and more carton grade potatoes (40.6% v. 32.9%) than the 7R18x18 method (Tables 4 and 5, p21). Tables 4 and 5 show the potato returns based on the price of two delivery or sale dates. The 12x36 method returned more dollars per cwt on both sale dates. The 7R18x18 method had higher gross returns on both sale dates, primarily due to a higher yield. Table 7 shows the economic return summary and the net profit. The 2005 cost of production of $2026 was modeled after Dr. Paul Patterson's cost of production estimates for stored and fumigated potatoes grown in southeastern Idaho (3). Neither of the study fields was fumigated, but expenses for both fields exceeded $2000 an acre according to the farm manager.

Soil moisture distribution (Table 8; Figures 13-15)

For a loamy, sand soil, as were both fields, the irrigation point (65% ASM) was estimated between 8-10% volumetric soil water content using TDR. A field capacity of 100% ASM was estimated between 14-16% volumetric soil water content (8). The distribution of soil moisture is shown in the 12x36 system (Figure 14, p23) and the 7R18x18 system (Figure 13, p23). Soil moisture content was more uniform across the bed in the 7R18x18 system than the 12x36 system. In the 12x36 system, the top-hill portion varied the most between 'wet' and 'dry' soil moisture, while the furrow remained 'wet' > 95% ASM through the potato irrigation season. This was mostly due to root system distribution where approximately 70% and 5% of the root mass was found in the top-hill area and furrow area, respectively. The furrow area accumulated soil-water due to the combined lack of rooting systems and crop-water-use, eventually reaching field capacity and soil-saturation where the excess moisture, along with dissolved solutes, drained to a lower soil depth.

In Table 8, the soil moisture data collected using TDR in fixed locations is shown. The coefficient of variation (CV) was higher on the 12x36 system (34.6%) than on the 7R18x18 system (11.9%). The CV was higher on the 12x36 system due to the obvious variances in soil moisture content between the top-hill, side-hill, and furrow in the row system. The soil moisture content after an irrigation event was more uniformly distributed in a bed system than in the row system.

In the bed system, when the beds are above 85% ASM from an over-irrigation or prolonged rainfall event the entire bed remains 'wetter' for a longer period of time as compared to the row system with similar soil water content. From July 9 to July 19, 3.22 acre-inches of water was applied to both fields, an average of 0.32 acre-inches per day (Figures 13-14, p23; Table 8, p22). This was too much for the beds, but the row system handled the over-irrigation better via the furrow. During June 1 to July 8, 6.16 acre-inches of water was received on the beds during the 38 day period, an average of 0.16 acre-inches per day. For the rows, 7.21 acre-inches were received resulting in an average of 0.19 acre-inches per day. However, during the same time period the beds remained 10% ASM or more 'wetter' than the rows. Furthermore, from July 21 to August 17, the daily average water amount was 0.21 acre-inches for the 7R18x18 method and 0.27 acre-inches for the 12x36 method. The soil moisture content between the beds and rows were similar during this time period, except for the furrow. This may provide evidence that the evaporation-transpiration rate, or ET, is less on the bed system than on the row system. The transpiration rate of the plants from the bed and row systems is probably the same. However, the evaporation rate from the soil is more likely much lower on the bed design than the row design. Therefore, the overall ET is most likely less on the bed system than the traditional row system. The findings from this project may suggest that irrigations on the bed designed systems should be at about 80-90% of the daily calculated ET's.

By July 19, the irrigation management errors were noticed and adjustments were made to dry the soil more in-between irrigation events. Thus, the soil moisture distribution showed a 'wetter' region in the middle of the bed (site 2) versus the outside of the bed (sites 1 and 3). Site 1 began drying out the quickest and actually had some soil moisture content below 65% ASM for the first time (Figure 13, p23). This makes sense since site 1 was closest to the south-wall of the bed. This is a priori evidence, but our elevated yield in US #2's may have resulted from this drying out in row #1. The bed went from too wet to almost too dry for the remainder of the season in site 1. Bed planting may be better with rows going north-south instead of east-west so that there are east- and west-walls instead of north- and south-walls. Also, small grade potatoes may have resulted from the middle-beds remaining too wet all season long.

Soil moisture measurements and irrigation management from June 1 to July 8

Total rainfall measured on the two project fields from June 1 to June 12 was 1.11 inches. Both fields were at field capacity during this time period and no irrigation events occurred. From June 13 to July 8, only 0.03 inches of rainfall occurred on both fields. From June 13 to July 8, there was an additional 5.05 acre-inches of irrigation-water applied to the 7R18x18 field and 6.10 acre-inches of irrigation-water applied to the 12x36 field. Thus, the total water from rainfall and irrigation from June 1 to July 8 was 6.16 acre-inches for the 7R18x18 method and 7.21 acre-inches for the 12x36 method.

The portable TDR soil moisture measurements showed that neither field fell below 75% ASM during June 1 through July 8. The furrow was the 'forgiveness-center' for the 12x36 method. The 12x36 method 'dried' quicker than the 7R18x18 method and consequently received an additional 1.05 acre-inches of water between June 13 and July 8. According to the portable TDR soil moisture data, the 12x36 method averaged 12.8% volumetric soil water content, which equates to around 80% ASM. The 7R18x18 bed method averaged 15.5% volumetric soil water content, which equates to nearly 100% ASM. The bed field was at or near field capacity from June 1 to July 8.

The 7R18x18 field was irrigated with 5.05 acre-inches during this time period, but this was too much. Irrigation events of 0.75 acre-inches occurred at around 80% ASM content. After the irrigation event, the soil moisture content rose to 100% ASM, or above, and stayed there for 2-3 days before declining again to around 80% ASM. The soil moisture content lasted longer in the bed design than what was expected. For example, on July 1 the TDR reading was 14.5%, or near 90% ASM. After waiting three days, the field was then irrigated with 0.75 acre-inches on July 4 and the TDR readings rose to 19.1%, which was above field capacity. This mistake of irrigating too quickly was made at least five times during June 13 to July 8 and the resulting effect was soil water content above 100% ASM.

Soil moisture measurement and irrigation management from July 9 to August 17

The soil moisture trend in the main root zone area for the 12x36 method and 7R18x18 method is shown in Figure 15, p.23. As mentioned previously, the main root zone area for the 12x36 method was in the top or top-hill where approximately 70% of the rooting mass was housed. The rooting system was probably more uniform or evenly distributed as compared to the row system. The soil moisture trends in Figure 15, p23, show a slightly 'wetter' trend in the beds than in the rows even though there was 1.5 acre-inches less water applied on the beds.

John Need a short section discussing deficiencies in study design (2 separate fields) and it impact (potentially) on the results

Evaluation of Project Goals and Objectives

(1) Was there a higher yield? Yes. However, the increased yield came mostly from an elevated level of US #2 and process grade potatoes on the 7R18x18 method. Improved techniques for irrigation scheduling and nitrogen management are needed. Also, a better-quality 'dammer-diker' that will improve soil water distribution at the middle of the bed and also at the outside-wall area may be needed.

(2) Was there a higher economic return? Yes and no. The 7R18x18 method returned more dollars per acre on the October 25, 2005 potato market. The 12x36 method had an increased dollar per acre returned on the January 20, 2006 potato market. As of February 14, 2006, the potato market has been more favorable to the 12x36 method. This was mainly due to more US #1's and larger tuber size from the 12x36 method. To increase the potential profitability of the 7R18x18 method over the 12x36 method, there must be a decrease in the yields of US #2's and process grade potatoes and an increase in US #1's and tuber size.

(3) Was there less power used per cwt produced? Yes. Both study fields have well-depths of 80-125 feet. There was 3.05 acre-inches less water applied on the 7R18x18 field than the 12x36 field. There were 53 cwt per acre more potatoes using the bed planting even though there was less water applied.

(4) Were there fewer fertilizer inputs per cwt produced? Fertilizer inputs were not reduced in this study. There were 1.28 cwt of potatoes produced per unit N applied on the 7R18x18 field. For the 12x36 field, there were 1.29 cwt of potatoes produced per unit N applied. Also, additional phosphorus and potassium were applied per acre on the 7R18x18 field. This was largely due to the over-zealous yield goal of 600 cwt. Next year a more likely yield goal of 500-525 cwt per acre will be attempted.

(5) Were there fewer pesticides applied per cwt produced? The amount of herbicides, insecticides, and fungicides for blight control were identical on both fields. Fostrol, a fungicide for water-rot, was applied three-times on the 12x36 field and only twice on the 7R18x18 field. Endura, a fungicide for blight and white-mold, was applied twice on the 7R18x18 field and only once on the 12x36 field. The 7R18x18 method produced a higher yield so it likely had fewer pesticides applied per cwt.

(6) Was water conserved? Yes. There was less water applied on the bed field. The 7R18x18 method had a season total of 15.87 acre-inches with a total yield of 471 cwt per acre. The12x36 method had a season total water amount of 18.92 acre-inches with a total yield of 418 cwt per acre. This translates to 29.7 cwt per acre for each 1 acre-inch of crop-received water for the 7R18x18 method and 22.1 cwt per 1 acre-inch for the 12x36 method.

Eight other fields planted with the bed planter

Of the other eight fields planted using the Spudnik bed planter, four of them were planted under wheel-line irrigation systems and the other three fields were planted under center pivot irrigation systems. Of the three fields in pivots, one of them was a wreck and yielded 300 cwt per acre (Ranger Russet). The other two pivot-fields both yielded 475 cwt per acre (Russet Burbank and Ranger Russets). The 300 cwt per acre field was definitely a wreck. It was irrigated ~~too wet~~ too often and suffered the consequences of root rot, white mold, and water rot. ~~Unfortunately, it was the result of a first year's learning experience~~. The four fields in wheel-lines produced a good crop. According to the farmer, all four fields yielded close to 400 cwt per acre. Not too bad considering that the fields were planted starting June 7th and vine-killed on September 15th. The 400 cwt seed yield was probably 50-60 cwt above the average of other fields that were also planted late due to late-season rainfall.

John: You probably don't need this section.

Conclusions

The main goals of this project were achieved. First, the 7-row bed planter was designed, built, and used in 2005. This was no easy feat. This is the only 7 row bed planter with an offset design and the capability of on-the-spot row and planter spacing changes available in the USA. The 7-row bed planter was finally designed in December 2004, manufactured by late March 2005, and used on the first field in late April. Most of the mistakes in managing the 7R18x18 system were due to inexperience and agronomic errors. Improvements in irrigation management and nitrogen management are crucial to the success of bed planting in southeastern Idaho. With improved management, the bed planting method is likely to reduce input costs per cwt, increase yield per acre, and conserve valuable resources such as water, power, and fertilizer.

References

(1) In the Background Summary, all financial and statistical data can be found at the following websites: http://www.ag.uidaho.edu/aers [click on resources]; and http://www.nass.usda.gov. [search for field crops {potatoes}; and Idaho].

(2) Guenthner, Joesph F. 2003. Principles of Economics and Marketing. Pg 384. *In* Stark, J. C., and S. L. Love (ed.) Potato Production Systems. University of Idaho Agricultural Communications, Moscow, Idaho.

(3) Bohl, W. H., and P. E. Patterson. January 2006. Costs of Production Still Matters Even With Good Prices. *In the* SPUDVINE, University of Idaho Cooperative Extension System.

(4) Personal interview with two of SPUDNIK's engineers from Germany.

(5) Personal interviews with farmers in the Aberdeen and American Falls area that have tried bed plantings of 5 and 6 row systems.

(6) Bohl, W. H., and S. L. Love. March 2004. Obtain A Uniform Stand. *In the* SPUDVINE, University of Idaho Cooperative Extension System.

(7) Stark, J. C., and D. T. Westermann. 2003. Nutrient Management. Pg. 115-127. In Stark, J. C., and S. L. Love (ed.) Potato Production Systems. University of Idaho Agricultural Communications, Moscow, Idaho.

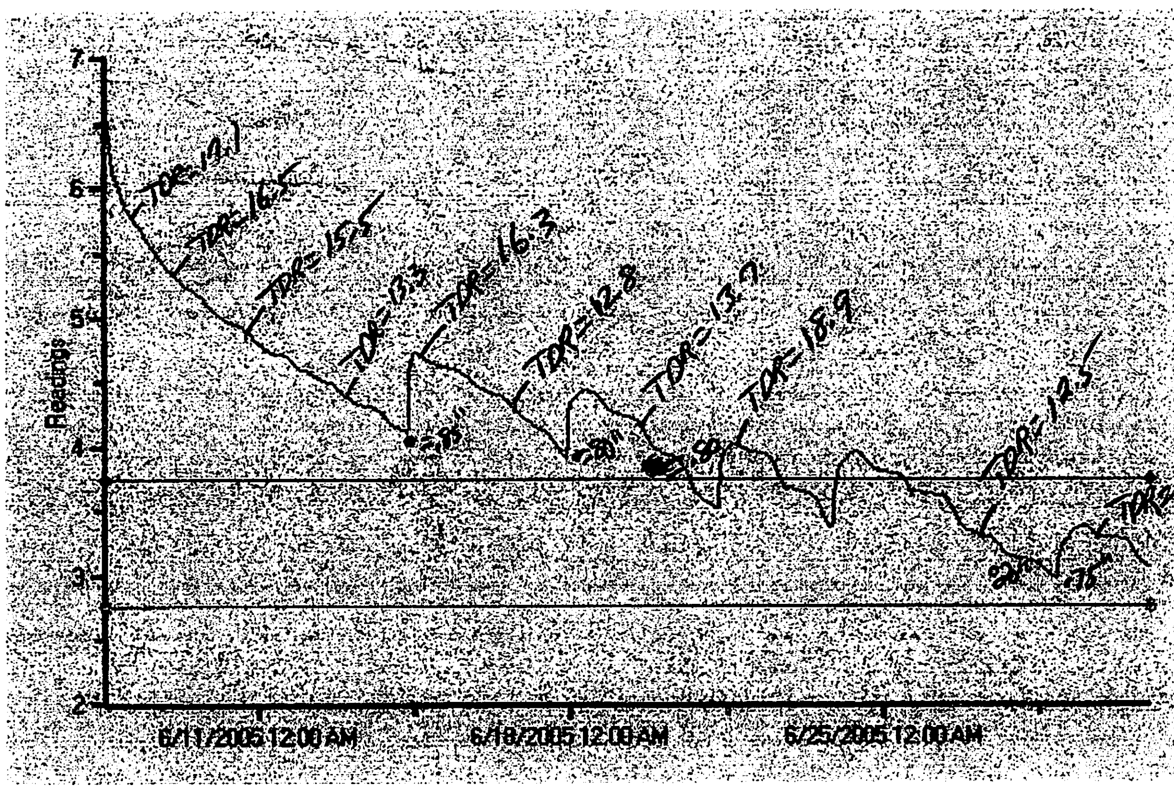
(8) King, B. A., and J. C. Stark. 1997. Potato Irrigation Management. BUL 789. University of Idaho Cooperative Extension System.

CROPSENSE

User:
WADA_FARMS

- Back to Probes
- Edit Probe Notes
- User Options
- Logoff

Sensor values for Probe 2:South on Logger: Potatoes Soil Type: Sandy Loam



Y-Zoom

50% 75% 100% 125% 150% 175% 200%

Sensors

- ☑ 4"
- ☑ 8"
- ☑ 12"
- ☑ 20"

All sensors are used in a Sum graph.

- Day
- Week
- Month
- Season
- Custom

6-01-2005
6-30-2005

- Line
- Stacked
- Sum

Create Graph

☐ Data Point

X-Zoom 50% 75% 100% 125% 150% 175% 200%

Budget Lines

Start Date	End Date	Full Point	Refill Point	Description
2005/04/24	2005/11/05	3.74	2.756	

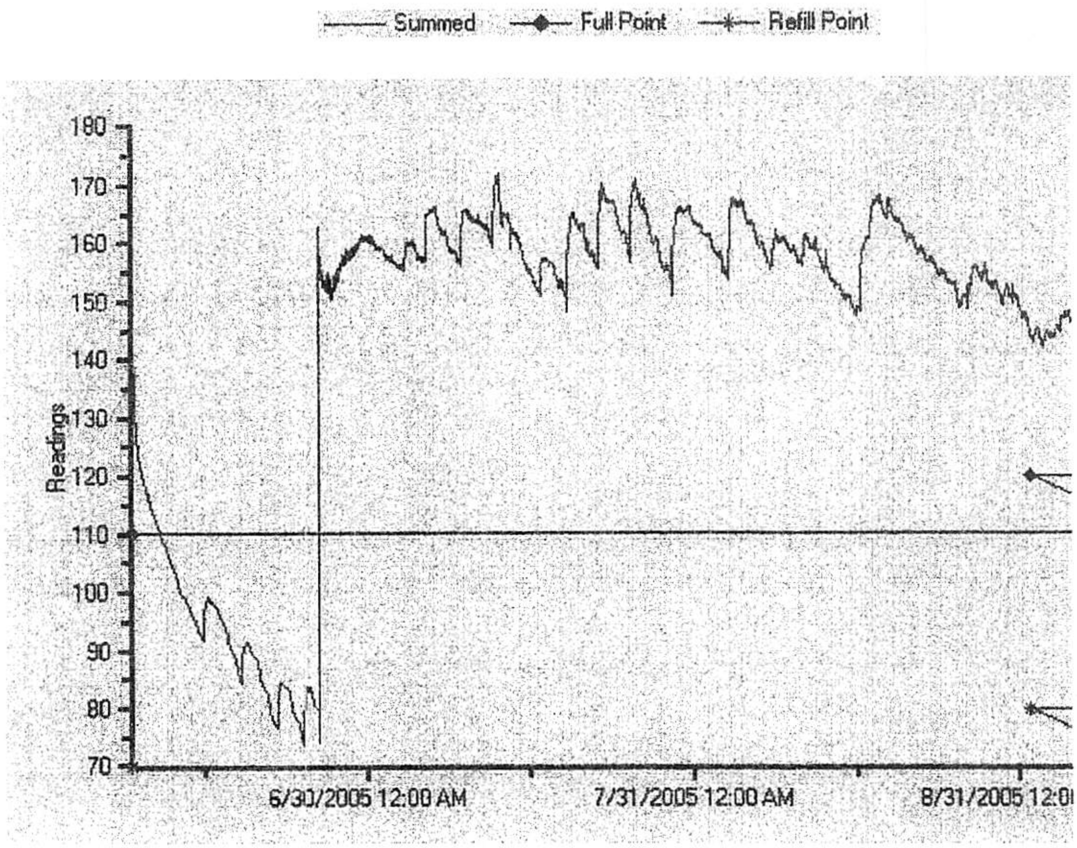
Notes

CropSense
IRRIGATION MANAGEMENT

User:
WADA_FARMS

Back to Probes
Edit Probe Notes
User Options
Logoff

Sensor values for Probe 1:North on Logger: Potatoes **Soil Type: S**



Day
Week
Month
Season
Custom
09-28-2005
09-28-2005

Line
Stacked
Sum

Create Graph
☐ Data Point

X-Zoom 50% 75% 100% 125% 150% 175% 200%

Budget Lines

Start Date	End Date	Full Point	Refill Point
2005/04/24	2005/11/05	110	70
2005/09/01	2005/11/30	120	80

Notes

Note	Created By	Created	Modi By