TECHNICAL NOTE

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Bed Planting for Sprinkler Irrigated Potato Production

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A group of people including farmers, researchers and equipment manufactures came together to implement a Conservation Innovation Grant (CIG) to refine the bed planting system in potatoes. Twenty three sites comparing the beds and ridge rows were evaluated. The project demonstrated that the enhanced utilization of space results in greater production per acre, with less water. Soil moisture data was collected comparing beds and ridge rows by Dr. Bradley King. The work indicates potatoes grown in the bed configuration produced higher yields with less water, so growers can reduce their water application by 5 to 15% and still maintain yields. A published journal article* by Bradley A. King and others concluded that planting potatoes in wide beds may improve water and nitrogen use efficiency due to a reduction in the amount of infiltration in the furrow, beyond the extent of much of the potato root zone. The wide bed planting systems provide a new opportunity to manipulate plant spacing to maximize use of available water and nutrient resources as well as target specific potato markets based on tuber size.

*B.A. King, D.D. Tarkalson, D.L. Bjorneberg and J.P. Taberna Jr. 2010**.** Planting System Effect on Yield Response of Russet Norkotah to irrigation and Nitrogen under High Intensity Sprinkler Irrigation. American Journal of Potato Research. DOI: 10.1007/s12230-010-9169-9

Bed Planting for

Sprinkler Irrigated Potato Production

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Acknowledgements

This project benefited greatly from the contribution of numerous individuals. They were willing to take some calculated risks and try something new to advance the understanding and use of bed planting in potato production. The dedication of these farmers and researchers is deeply appreciated and deserving of much gratitude.

Participating Farms

Albert Wada Potatoes
Cedar Farms Inc.
Idaho Falls Idaho Crops – Mark Thompson
DC Farms
Garth Van Orden Farms
Kevin Loveland Farms
Lance Funk Farms
Larry Nederer Potatoes
Mark Mickelsen Farms
Morgan's Pasture
Nonpareil Farms
Reed Searle Farms
Tominaga Farms
Walters Produce
Wilcox Brother's Potatoes

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Potato Equipment Manufacturers

Lockwood-Harriston, Norman Landon and Aaron Savage, Sales Representatives
Spudnik, Frank Dorenkamp, Engineer

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John Taberna, Jr., Research Agronomist with Western Ag Research LLC, was the principle investigator on this project and author of this publication. The results and suggestions are based upon the growing conditions found in eastern Idaho, at an elevation of 4,200 to 5,300 feet.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author and do not necessarily reflect the view of the U.S. Department of Agriculture or the participating farmers.

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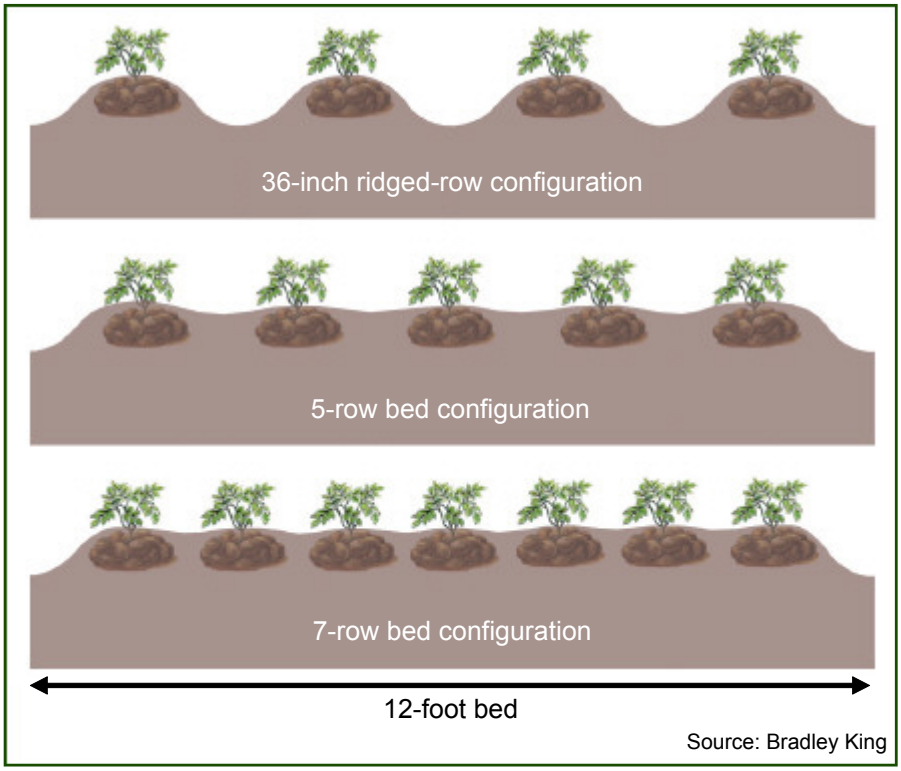
The Benefits of Bed Planting

Potatoes have traditionally been planted in ridged rows. In the irrigated West, the ridged row originally provided a furrow for surface irrigation and drainage. While irrigation methods have changed significantly over the decades, the ridged-row planting configuration has remained.

In recent years, farmers and researchers across the West have started considering the benefits of a bed planting configuration. In a bed design, multiple rows of potatoes are planted into an elevated, flat area. This configuration reduces the number of furrows in a field, thus increasing the surface area for optimal distribution of potato roots.

In a ridged-row configuration, more than 50% of the land area is occupied by ridges and furrow space. In beds, the ridges and furrow space are reduced to less than 30%. With this space savings, more potato plants can be grown in the field. In addition, plants can be more optimally spaced for enhanced light interception.



The ridged-row planting configuration commonly consists of four 36-inch spaced rows (top) in a 12-foot section. In contrast, a bed planting configuration places either five rows (middle) or seven rows (bottom) in the same 12-foot section.

Field preparation prior to planting a 12-foot bed configuration (left) and a typical ridged-row configuration (right).

The inner three furrows were removed in the bed, leaving only the furrows along each side. The elevated-bed configuration reduces furrow space and houses the root system in a more spatially distributed fashion than in a ridged-row configuration.

Typical Idaho potato production equipment can easily be used on this 12-foot bed, including 4-row windrowers and harvesters.

Not only are potato growers better able to utilize their limited land resources with the bed planting configuration, they can also reduce water. Published root distribution data show that at most 25% of potato roots are distributed in the furrow, with the remaining 75% or more of the roots located in the hill or slightly below the hill. By eliminating the furrows in a bed format, roots are able to grow in a greater horizontal area. The additional horizontal root growth can support increased nitrogen uptake and water use efficiency.

Increased nitrogen uptake and water use efficiency in bed-planted potatoes keeps production costs down, at a time when resource costs have significantly increased without corresponding production gains.

The goals of this project were to refine the bed planting system and demonstrate that the enhanced utilization of space results in greater production per acre, with less water.

Most participating growers in this project found the bed configuration to be an innovative farming technique with the potential to increase yields by 35 cwt per acre, without increasing input costs.

5-Row Bed Planter Specifications

Bed size
12-foot bed width with 40-inch 'guess rows'

Row Spacing
26 inches between rows

In-row Plant Spacing
Adjustable between 6 and 26 inches

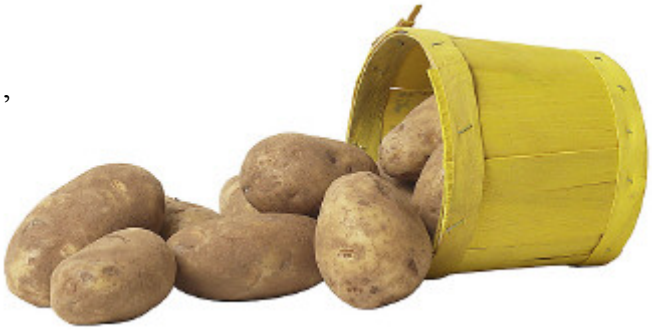
	Plant Population (plants per acre)	
In-row Seed-piece Spacing (inches)	36-inch rows	5-row beds
8	21,780	27,225
10	17,424	21,780
12	14,520	18,150
14	12,446	15,557
15	11,616	14,520

7-Row Bed Planter Specifications

Bed size
12-foot bed width with 36-inch 'guess rows'

Row Spacing
18 inches between rows

In-row Plant Spacing
Adjustable between 6 and 26 inches



In-row Seed-piece Spacing (inches)	Plant Population (plants per acre)	
	36-inch rows	7-row beds
8	21,780	38,115
10	17,424	30,492
12	14,520	25,410
14	12,446	21,781
21		14,520

Soil Moisture Profiles of Ridged-Row and 5-Row Bed Configurations

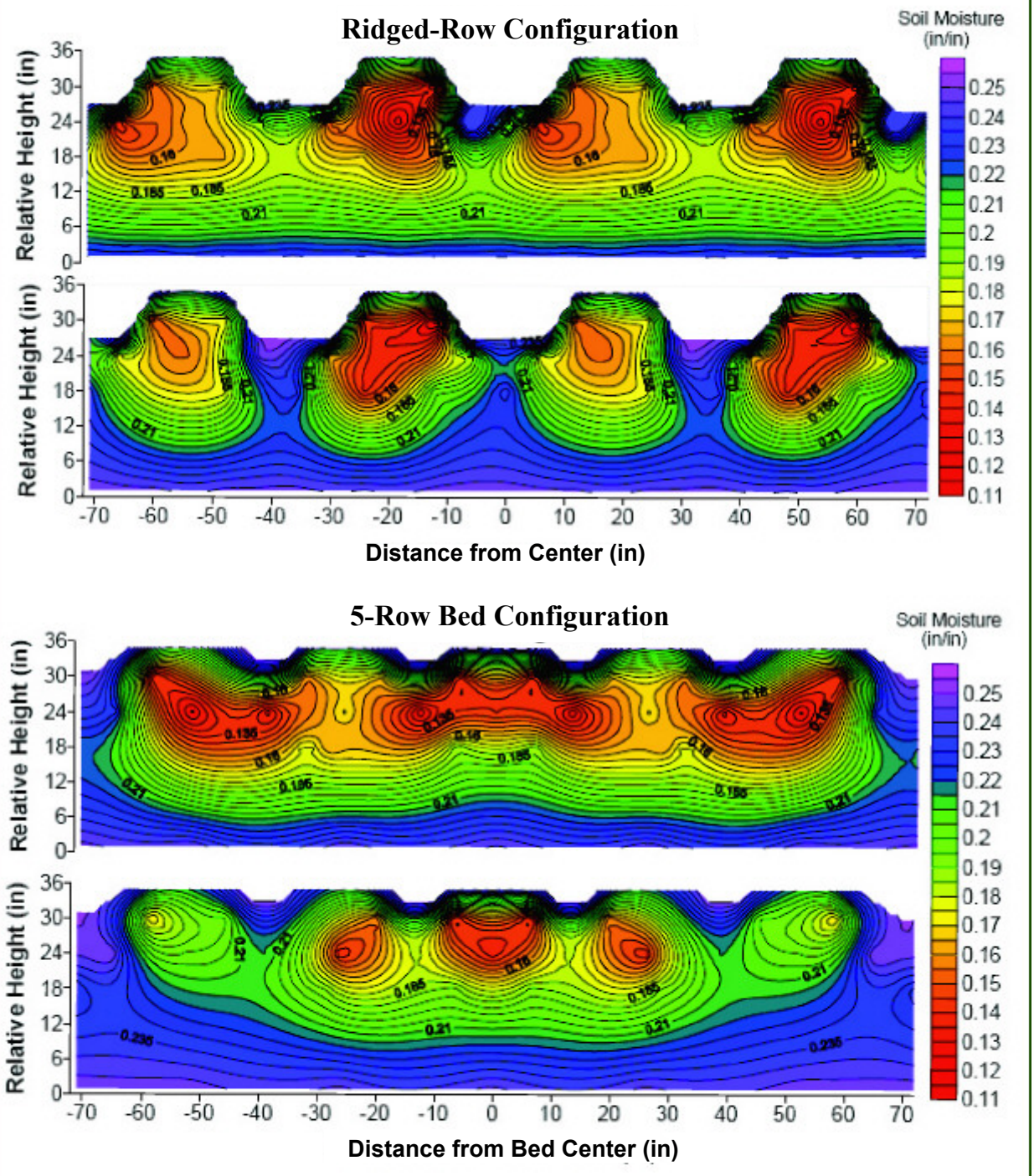


Figure 1: Soil moisture in ridged-row and 5-row bed configurations at 1 hour before (top panel in each pair) and 6 hours after a 1 acre-inch irrigation event (bottom panel in each pair). Data were collected by Dr. Bradley King of USDA ARS – NWISRL, under a linear-move irrigation system near Blackfoot, Idaho.

Soil Moisture Before and After Irrigation in Ridged-Row and Bed Configurations

Figure 1
Soil moisture data were collected in potatoes grown in beds and ridged rows under a linear-move irrigation system in a loamy sand soil in Blackfoot, Idaho. Dr. Bradley King of USDA ARS – NWISRL installed soil moisture monitoring devices and recorded soil moisture multiple times each day. Figure 1 shows one irrigation event. Soil moisture values at 1 hour prior to irrigation (top panel in each pair) and 6 hours after (bottom panel in each pair) a 1 acre-inch irrigation event are shown for potatoes grown in beds and ridged rows.

Most of the water concentrated in the furrow in the ridged-row configuration, thus bypassing the main mass of roots located in the hill.

The water was distributed more uniformly in the bed configuration and did not migrate beyond the roots. Following irrigation, the wettest area in the bed configuration was along the outside edge in the furrow.

The different patterns of water distribution in the two planting configurations explain the enhanced water conservation experienced in the bed-planted potatoes.

Water and Nitrogen Conservation Results

Table 1. Total yield of Russet Norkotah potatoes grown in ridged rows and beds at three different irrigation levels.

	Percentage of Evapotranspiration (ETs)		
	80% ET 21.0 inches	**90% ET 23.6 inches**	**100% ET 26.2 inches**
Planting Method	**Yield (cwt/acre)**		
Ridged rows (12 x 36)	321	393	406
Bed: 5-row (14 x 26)	369	404	428
Bed: 7-row (18 x 18)	391	428	444

Source: Dr. Bradley King, USDA ARS – NWISRL, unpublished data
Data were obtained from USDA ARS – NWISRL replicated research plots in Kimberly, Idaho planted with standard Russet Norkotah potatoes in 2006 and 2007.

Table 2. Total yield per unit nitrogen applied of Russet Norkotah potatoes grown in ridged rows and beds at three different irrigation levels. Potatoes were grown with 200 lb N per acre.

	Percentage of Evapotranspiration (ETs)		
	80% ET 21.0 inches	**90% ET 23.6 inches**	**100% ET 26.2 inches**
Planting Method	**Yield (cwt/lb N)**		
Ridged rows (12 x 36)	1.61	1.97	2.03
Bed: 5-row (14 x 26)	1.85	2.02	2.14
Bed: 7-row (18 x 18)	1.95	2.14	2.22

Source: Dr. Bradley King, USDA ARS – NWISRL, unpublished data
Data were obtained from USDA ARS – NWISRL replicated research plots in Kimberly, Idaho planted with standard Russet Norkotah potatoes in 2006 and 2007.

Table 1. Total yield of Russet Norkotah potatoes grown in ridged rows and beds at three different irrigation levels.

At 80% of ET, Norkotah potatoes grown in beds produced a higher yield than those grown in ridged rows. At this irrigation level, an additional 2.3 cwt were produced per inch of water applied in 5-row beds and 3.3 cwt were produced per inch of water applied in 7-row beds as compared to the rows. Yields were more similar for Norkotah potatoes grown in ridged rows and beds at typical irrigation levels of 90% and 100% ET.

✓ Potatoes grown in the bed configuration produce higher yields with less water, so growers can reduce their water applications by 5 to 15% and still maintain yields.

Table 2. Total yield per unit nitrogen applied of Russet Norkotah potatoes grown in ridged rows and beds at three different irrigation levels.

At all three irrigation levels, Norkotah potatoes grown in beds produced a slightly higher average yield per unit of nitrogen applied. At 200 pounds nitrogen applied, Norkotah potatoes grown in the 5-row and 7-row bed systems produced an average15 lbs more potatoes per lb N applied than the rows.

✓ Potatoes grown in the bed configuration showed higher yields per unit nitrogen applied. This was likely due to increased nitrogen uptake by the more horizontal and evenly distributed roots in beds than in the ridged rows. In the ridged rows, the nitrogen likely moved with the irrigation water, thus bypassing the roots and moving into the furrow.

Field Testing Conditions

Western Ag Research, along with our research partners and the participating farmers, field tested the bed planting configuration from 2004 to 2008 in eastern Idaho. We will continue to further refine the method with additional field tests through 2012. With assistance from a USDA grant, Western Ag Research developed a 5-row and 7-row bed planting system. This work in Idaho has given numerous potato growers the opportunity to explore the technology with only limited expense. We have encouraged the use of bed planters with several different potato varieties and field sizes from 40 to 160 acres.

In addition, replicated field trials have been conducted over the last three years at the USDA ARS – NWISRL field site in Kimberly, Idaho.

Information gained from both commercial fields and replicated trials have been incredibly important for developing and refining the bed planter technology and management methods. The on-farm testing has been essential to increasing grower adoption of the technology.

Field Locations

All growers' fields in this project were located in eastern Idaho. The fields were situated between the towns of Rexburg and American Falls.

The USDA ARS test site was located in Kimberly, Idaho on a nine-acre farm under linear-move irrigation. Research was conducted by Bradley King, David Tarkalson, and David Bjorneberg.

Acres

Since 2004, Idaho growers have bed-planted potatoes on more than 8,000 acres on a commercial basis. Western Ag Research's project has included roughly 6,500 of those acres.

Soil Types

The potato bed planters were field tested on soils that varied from sands to silt loams.

Potato Varieties

Alturas
Cal-White
Potandon Produce proprietary varieties
Purple lady
Ranger Russet
Red-skinned potatoes
Russet Burbank
Selection Russet Norkotah
Sierra Gold
Standard Russet Norkotah
Umatilla
Varieties for seed potato production
Western Russet
Yukon Gold

Irrigation Types

The bed planting configuration was field tested under several sprinkler irrigation system types, including hand lines, wheel lines, linear-move lines, and center pivots.

2007 and 2008 Grower Field Test Results

Table 3. Yields of potatoes grown in 23 side-by-side comparisons of beds and ridged rows on participating farmers' fields.

		Beds			Rows			
Test Site	Variety	Yield (cwt/acre)	Water Applied (inches)	Yield/water applied (cwt/inch)	Yield (cwt/acre)	Water Applied (inches)	Yield/water applied (cwt/inch)	Acres*
1	Norkotah (Tx112)	474	19.3	24.6	418	18.5	22.6	121
2	Norkotah (Tx112)	491	13.2	37.2	479	13.6	35.2	189
3	Sierra Gold	460	18.5	24.9	335	19.1	17.5	205
5	Norkotah (Tx112)	460	26.8	17.1	385	27.7	13.9	320
4	Norkotah (Tx112)	404	21.5	18.8	303	20.9	14.5	315
6	Reds	418	20.0	20.9	390	20.0	19.5	340
7	Russet Burbank	419	22.5	18.6	371	20.4	18.2	105
8	Norkotah (S-3)	427	20.5	20.8	454	18.9	24.0	110
9	Norkotah (S-3)	419	20.4	20.5	410	22.7	18.1	270
10	Russet Burbank	475	20.5	23.2	455	23.8	19.1	320
11	Norkotah (Tx112)	436	20.9	20.9	402	22.9	17.6	160
12	Norkotah (Tx278)	497	23.0	21.6	435	23.9	18.2	340
13	Norkotah (Stand)	391	13.2	29.6	491	16.6	29.6	200
14	Norkotah (Stand)	401	14.1	28.4	381	16.5	23.1	318
15	Russet Burbank	310	17.2	18.0	385	17.2	22.4	320
16	Alturas	392	21.5	18.2	380	21.5	17.7	40
17	Reds	315	16.4	19.2	375	19.3	19.4	210
18	Rangers	300	19.4	15.5	365	18.3	19.9	310
19	Rangers	444	17.4	25.5	390	18.8	20.7	310
20	Norkotah (S-3)	460	21.0	21.9	427	23.2	18.4	210
21	Russet Burbank	415	22.9	18.1	445	24.9	17.9	210
22	Norkotah (S-3)	457	23.8	19.2	420	23.8	17.6	140
23	Russet Burbank	471	15.9	29.6	418	18.9	22.1	210
	Average	**423**	**19.6**	**21.6**	**405**	**20.5**	**19.8**	**5,273**
								Total Acres

* This is the combined number of acres for both beds and rows at each field test site.

Summary of Grower Field Test Results

- Table 3 shows 23 side-by-side field comparisons of potatoes grown in beds versus ridged rows. An additional 42 fields have been planted with beds in this project, but were not grown in a side-by-side comparison with ridged rows. Only those fields with side-by-side comparisons are shown.
- Potato yields were collected and reported by the participating farmers.
- In 17 out of the 23 side-by-side field comparisons of potatoes grown in beds versus ridged rows, the potatoes grown in beds produced a higher yield. Overall, yields for potatoes grown in beds were 18 cwt per acre greater than for potatoes grown in ridged rows.
- The additional yield of 18 sacks per acre in the bed system was produced along with a savings of 0.9 inches of water.
- Russet Norkotah and specialty potatoes, such as red- and yellow-skinned varieties, have been the best performers in the bed planting system.

Challenges and Solutions

During the initial phase of adoption, the bed planting system created some challenges. Western Ag Research and our participating farmers made modifications to improve the performance of the bed planting system, including adjusting the bed planters, altering water management, and modifying seeding rates. Growers using the bed system for the first time need to be aware of the following three potential problems:

A) planting too dense,

B) over watering on sandy soils, and

C) uneven soil moisture on some silt loam soils.

Challenge: Planting too dense.

Planting density depends upon the desired tuber size profile and intended market. A dense planting in beds can be beneficial for obtaining a smaller tuber profile, such as for red- and yellow-skinned varieties. In contrast, a dense planting in beds of varieties where a larger tuber profile is desired, such as for Russet Norkotah and Russet Burbank potatoes, has had a negative impact on financial returns.

➔ **Solution:**
Consult with experienced growers and crop advisors to determine the correct plant spacing for each potato variety and market.

Recommended plant population adjustments for beds as compared to ridged rows:

- Plant normal rates up to an additional four sacks more per acre for larger sized profile tubers, such as Russet Burbank and Norkotah.
- Plant normal rates up to an additional seven sacks per acre for varieties where smaller tuber size is desired, such as Yukon Gold, Sierra Gold, and red-skinned varieties.
- Increase plant populations, if the crop is to be raised an additional 2 to 3 weeks.

Challenge: Over watering on sandy soils.

Initially we predicted that additional water and fertilizer would be needed because more plants per acre could be grown in beds. Our experience proved otherwise. This was especially true for potatoes grown in beds on sandier soils. For reasons unknown to date, beds on sandier soils require less water than in rows. This is not always the case, as with silt loam soils described below.

➔ **Solution:**
Closely monitor crop irrigation needs, since requirements on sandier soils can be difficult to discern.

Recommended irrigation adjustments for beds as compared to ridged rows:

- On sandy loam and loamy sand soil types, growers can expect to reduce water use by up to 15%.
- On loam soils, growers can expect to reduce water use by up to 10%.
- Potatoes irrigated with hand lines or wheel lines often require 15 to 20% less water.

Challenge: Uneven soil moisture on some silt loam soils.

The combination of center pivot irrigation on silt loam soils has produced the most variable yields for potatoes grown in beds. While inconsistencies were most common with Russet Burbank potatoes, variability was also found in some fields of Russet Norkotah potatoes and specialty varieties. Uneven soil moisture is the likely problem for beds in silt loam soils under center pivot irrigation. Variability was most pronounced in Russet Burbank potatoes, likely because this variety is highly sensitive to water stress.

➔ **Solution:**
When growing potatoes under center pivot irrigation in silt loam soils, carefully manage soil moisture to ensure uniformity across the bed and consider using a dammer-diker.

Recommended adjustments for potatoes grown in beds in silt loam soils under center pivot irrigation:

- Use a dammer-diker to increase soil moisture uniformity across beds in silt loam soils. Some of the farmers who participated in this project developed a dammer-diker system for beds, consisting of two normal sized paddles on the outside and sugar beet style paddles between the inner rows.
- Decrease the amount of water applied with the first irrigation on silt loam soils. The participating farmers determined that more uniform soil moisture was achieved by applying 0.3 to 0.5 inches. This adjustment may require more irrigation rotations, initially, on a bed system per irrigation event.

Keys to Success When Using Bed Planters

1. **Planter Selection**
   Planter selection depends upon the variety grown and desired tuber size profile. The 7-row planter performs well with varieties where small tubers are desired, such as specialty type potatoes (fingerlings, purple-ladies, red-and yellow-skinned varieties). The 5-row planter performs well with varieties where larger size profiles are desired, such as for Russet Burbank and Russet Norkotah potatoes.

2. **Plant Population Selection**
   The participating growers in eastern Idaho have found that typical plant populations up to an additional four cwt are best for growing Russet Burbank and Russet Norkotah potatoes in beds. Because specialty varieties have such a wide range of preferred market sizes, it is best to consult with the potato buyer to determine plant density.

3. **Irrigation Management**
   For more than 80% of the fields examined, bed-planted potatoes required less water than potatoes grown in ridged rows. This water savings was subtle per irrigation event, but could be maintained season long. If the normal irrigation was 0.75 inches from a pivot per rotation on ridged rows, it could be reduced to 0.60 to 0.65 inches on bed-grown potatoes.

4. **Fertilizer Management**
   Most participating growers have found that nitrogen, phosphorus, and potassium needs for potatoes grown in beds are the same as for potatoes grown in ridged rows. However, a few have seen a savings of 25 pounds per acre of nitrogen in their bed-grown potatoes.

5. **Consultation with Experienced Growers**
   Some Idaho growers have been using bed planters for four years, now. Talk with these growers or Western Ag Research to learn how to enhance potato production with the use of bed planting.

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