

# Performance of Potatoes Under Irrigation at Oakes, North Dakota

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Potatoes are one of the crops considered to have potential for large scale production once irrigation is available in the Oakes area of North Dakota. The present study was undertaken to evaluate the production potential, quality and harvest period for varieties grown in that area. The trials were conducted on a Maddock sandy loam. A complete description of the research site within the West Oakes Irrigation District is given in an earlier publication (1).

## Procedure

The three varieties used in these trials were Norchip, an early to mid-season white-skinned variety, usually grown for processing; Norland, an early red-skinned variety widely grown for table use; and Russet Burbank, a very late maturing russet-skinned variety that is especially popular in irrigated areas. Each variety was grown at three spacings (8, 12 and 16 inches) between hills in rows 36 inches apart. Plantings were made the last week of April in each of the three years, and fertilized with nitrogen, phosphorus and potassium at rates considered adequate for at least 400-450 cwt/acre yields based on soil tests. Plants were sprayed and cultivated during the season as needed to control insects, diseases and weeds. Vines were removed the day before harvest. In each year, harvests were made on three dates.

Irrigations were supplied with a plot irrigator. Water applications were scheduled at the discretion of the station manager with a frequency that minimized the likelihood of production-limiting stress periods.

Root zone soil moisture was monitored in each growing season by the neutron scatter method. Ten access tube sites were distributed over the plot area with placement primarily in the Norchip and Russet Burbank, or the longer season varieties. Moisture measurement was made at approximate weekly intervals to a depth of 4 feet.

Irrigation amounts were monitored by placing a catch can near each access tube site. Kerosene was used as an evaporation suppressant.

After harvest, potatoes were taken to Fargo for grading and sizing. Culls (tubers that were excessively malformed, knobby, green or had severe growth cracks) were first graded out. There-

fore, tubers that were either over or under-sized as well as being culls would be counted only in the cull class. After grading, tubers were sized on a spool-type sizer.

## Results and Discussion

### Growing Conditions

Precipitation, irrigation water and mean monthly temperatures during the growing season are shown in Table 1. Temperatures during June 1971, May 1972, and August 1973 were considerably above normal, while July 1971, and July 1972 were considerably below. Precipitation, supplemented with irrigation, totaled between 23.85 and 25.31 inches for the growing season.

Table 1. Temperatures, Precipitation and Irrigation at the Oakes Irrigation Site 1971-73.

	1971	1972	1973	Normal For Oakes
<b>Mean Monthly Temperature (F)</b>				
May	54.4	57.4	54.5	54.2
June	68.5	64.9	65.6	64.1
July	67.1	67.4	69.8	70.4
August	68.3	68.6	72.4	69.0
September	58.1	56.4	56.5	
Average	63.3	62.9	63.8	
<b>Precipitation Plus Irrigation</b>				
May	1.47	6.03	1.85	
June	5.65	3.90	4.51	
July	7.19	9.58	5.95	
August	11.00	5.00	7.87	
September	0.00	0.15	3.67	
Total	25.31	24.66	23.85	

### Yields and Specific Gravity

Total yield (Table 2) consisted of all sound potatoes over 1½ inches in diameter. Each year the first harvest was made during late July or early August. By August 10, 1971 yields of Norchip and Norland were around 300 cwt/acre; therefore, harvesting was progressively earlier in 1972 and 1973 to establish the earliest possible date that substan-

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**Table 2. Influence of Spacing and Harvest Date on Total Yield of Norchip, Norland and Russet Burbank Potatoes, 1971-73.**

Date of Harvest	Norchip (cwt/acre)				Norland (cwt/acre)				Russet Burbank (cwt/acre)			
	Spacing Between Hills				Spacing Between Hills				Spacing Between Hills			
	8"	12"	16"	Average	8"	12"	16"	Average	8"	12"	16"	Average
Aug. 10, 1971	316	294	243	284	316	288	279	294	181	169	153	168
Aug. 1, 1972	303	278	295	292	351	296	274	307	216	199	184	200
July 26, 1973	213	208	182	201	198	199	171	189	77	81	62	73
Average	277	260	240		288	261	241		158	150	133	
Sept. 1, 1971	414	443	410	422	404	411	349	388	389	341	318	349
Aug. 16, 1972	383	403	334	373	371	366	356	364	305	278	283	289
Aug. 9, 1973	296	293	281	290	273	268	264	268	160	172	169	167
Average	364	380	342		349	348	323		285	264	257	
Oct. 1, 1971	474	455	484	471	407	421	399	409	410	414	372	399
Sept. 25, 1972	412	453	418	428	363	363	358	361	369	319	345	344
Sept. 26, 1973	403	428	384	405	334	299	310	314	388	393	396	392
Average	430	445	429		368	361	356		389	375	371	

tial yields could be obtained. Russet Burbank was considerably lower-yielding than the two early varieties at the early harvest date, and the length of the growing season was probably an important factor in limiting the ultimate yields of Russet Burbank. Norland was the earliest maturing variety, growing very little, if at all, after mid-August.

Seed piece spacing had some influence on yields with the closer spacings usually increasing the yield. The spacings shown in the tables were indicative of the plant populations finally established. There was very little, if any, seed decay, and plant stands average between 95 and 97 per cent of the possible maximum in each of the three years. The closer spacings also resulted in better weed control; however, cost of seed in relation to value of production are important in determining the most profitable spacing for each variety.

Of most commercial importance are the marketable yields (Table 3). Culls and tubers not meeting certain size specifications may in fact be

a financial liability. Norland had a slight edge over Norchip in early production of marketable tubers. The two earlier varieties were about even in mid-August, but by the last harvest Norchip was the heaviest producer. Russet Burbank needed the whole growing season to produce the good yields needed to pay irrigation costs. Even when harvested late, it did not reach the yields of Norchip but was about equal to Norland.

The yield of non-marketable tubers varied with variety, time of harvest and spacing. Norland consistently had the lowest percentage of non-marketable tubers, averaging 11.2 per cent of total yield. Corresponding percentages for Norchip and Russet Burbank were 17.8 and 22.8 per cent, respectively.

The percentage of non-marketable tubers was about equal for the three harvests. At the early harvest, most of the non-marketable tubers consisted of those under 1 $\frac{1}{8}$ -inch in diameter in all varieties. By the second harvest, the non-mar-

**Table 3. Influence of Spacing and Harvest Date on Marketable Yield of Norchip, Norland and Russet Burbank Potatoes, 1971-73.**

Date of Harvest	Norchip (cwt/acre)				Norland (cwt/acre)				Russet Burbank (cwt/acre)			
	Spacing Between Hills				Spacing Between Hills				Spacing Between Hills			
	8"	12"	16"	Average	8"	12"	16"	Average	8"	12"	16"	Average
Aug. 10, 1971	267	258	212	246	290	266	250	269	133	135	115	128
Aug. 1, 1972	268	236	254	253	315	260	250	275	151	149	134	145
July 26, 1973	164	163	154	160	169	176	151	165	49	50	36	45
Average	233	219	207		258	234	217		111	111	95	
Sept. 1, 1971	345	352	304	334	368	364	304	345	313	282	243	279
Aug. 16, 1972	340	349	284	324	322	319	316	319	236	232	227	232
Aug. 9, 1973	252	223	221	232	241	236	237	238	113	128	122	121
Average	312	308	270		310	306	286		221	214	197	
Oct. 1, 1971	401	366	360	376	361	367	345	358	351	342	287	327
Sept. 25, 1972	363	374	341	359	319	319	304	314	307	246	275	276
Sept. 26, 1973	340	321	266	309	304	270	275	283	322	319	319	320
Average	368	354	322		328	319	308		327	302	294	

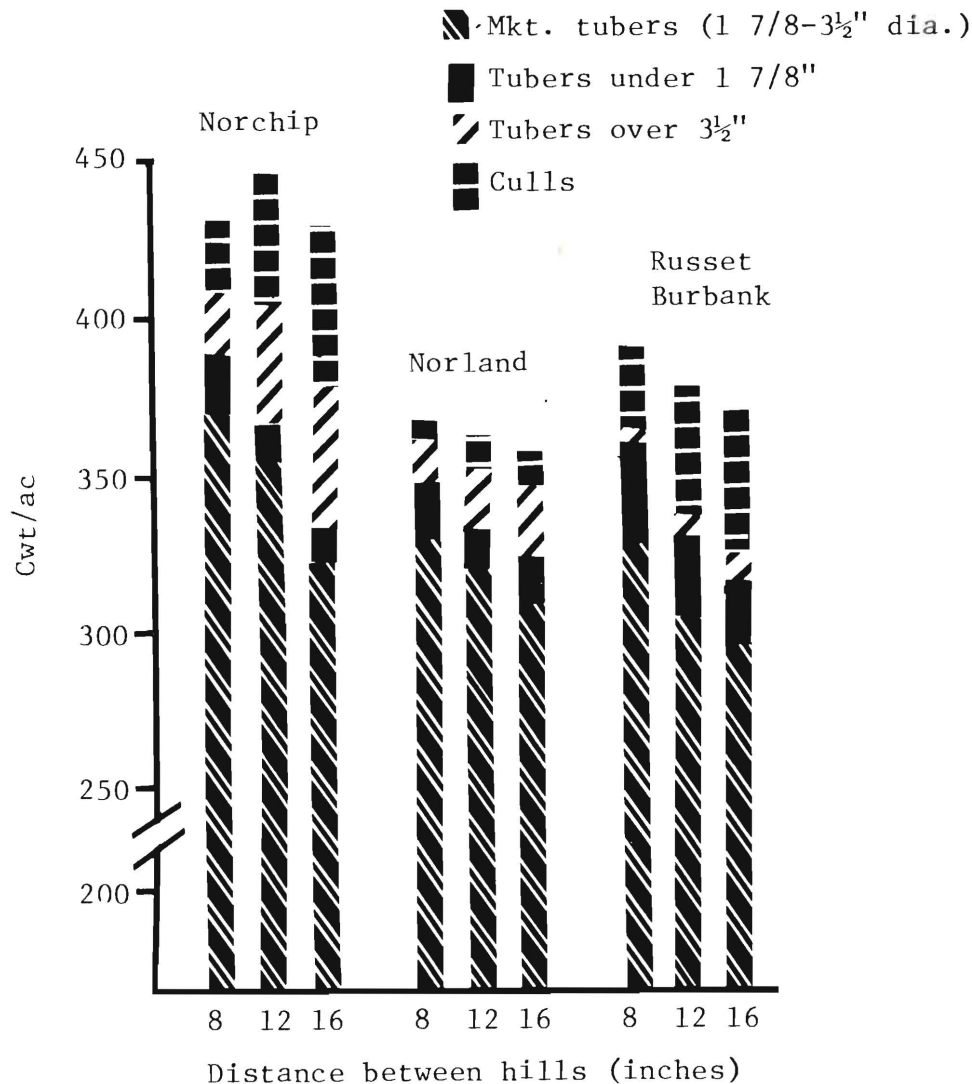


Figure 1. Field plot layout to study effect of nitrogen source on Waldron wheat, Oakes, North Dakota.

marketable tubers consisted of a mix of small, large and cull tubers, with the proportion of each varying with spacing and variety. Culls were highest in the Russet Burbank variety.

In the Norchip variety, the percentage of non-marketable tubers was lowest with the eight-inch spacing. As the spacing increased there was a large increase in oversized and cull tubers. The percentage of non-marketable tubers was not affected by spacing of Norland and Russet Burbank, but with Russet Burbank there was a large shift from the small to the cull class with an increase in spacing.

The distribution of tubers for each spacing at the last harvest, averaged for three years, is presented in Figure 1. Norchip, with the largest total yield, had most of the non-marketable tubers in the cull and oversize classes when spacing was greater than eight inches. Norland was the lowest

yielding variety, but had the smallest percentage of non-marketable tubers.

The non-marketable tubers of the Russet Burbank variety were primarily either in the small or cull classes. This was because most of the very large tubers were also culls and because of the type of sizer used. With a spool-type sizer, a long-type variety (Russet Burbank) averages more by weight for a given tuber diameter than a round or slightly oblong tuber like Norchip or Norland. Therefore, the tubers classed as small in the Russet Burbank variety actually would be heavier than Norchip and Norland tubers.

Specific gravity is a good indicator of the total solids content of potato tubers. A high solids content usually is desirable because there is less water and more starch, protein, minerals and other food constituents in the tuber. Potatoes raised under irrigation usually have a lower specific gravity than those raised on dry land. There also

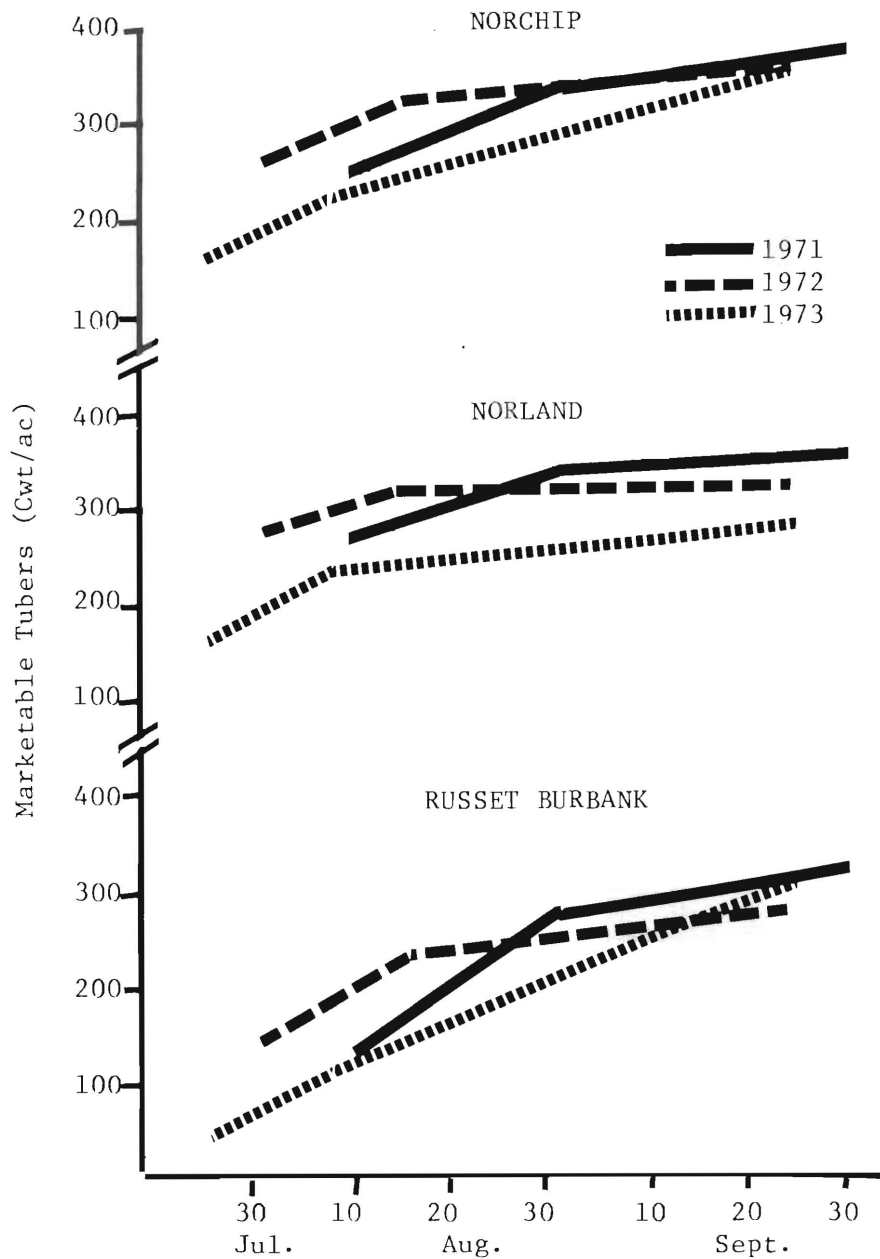


Figure 2. Cumulative amounts of N, as  $\text{NO}_3$ , at harvest under wheat and corn supplied with four fertilizer N rates at planting, 1973.

are substantial differences between varieties, time of harvest and other cultural factors.

Norland was consistently the lowest in specific gravity (Table 4). Between Norchip and Russet Burbank, Norchip usually was highest on the earlier harvests, while the reverse occurred on the last harvest. Spacing had no influence on specific gravity. Specific gravity of all varieties was high enough for tubers to be satisfactory for their usual uses. Norchip and Russet Burbank are two varieties that are consistently among the highest in specific gravity of those grown in this area, while Norland usually is medium to low.

The development of marketable tubers averaged over spacings is shown in Figure 2. Development of Norland was early, and growth ended before the other varieties. Tuber development in Russet Burbank was slow, but continued later than with Norland and Norchip. Probably only with Russet Burbank could significantly larger yields have been achieved with a longer growing season.

#### *Yields Versus Water Use*

A water balance model as previously described by Stegman and Valer (2) was used to estimate

**Table 4. Influence of Spacing and Harvest Date on Specific Gravity of Norchip, Norland and Russet Burbank Potatoes, 1971-73.**

Date of Harvest	Norchip Spacing Between Hills				Norland Spacing Between Hills				Russet Burbank Spacing Between Hills			
	8"	12"	16"	Average	8"	12"	16"	Average	8"	12"	16"	Average
Aug. 10, 1971	1.095	1.091	1.090	1.092	1.080	1.077	1.079	1.079	1.088	1.092	1.085	1.088
Aug. 1, 1972	1.085	1.084	1.086	1.085	1.077	1.072	1.076	1.075	1.080	1.081	0.083	1.081
July 26, 1973	1.075	1.077	1.075	1.076	1.068	1.067	1.066	1.067	1.070	1.071	1.066	1.069
Average	1.085	1.084	1.084		1.075	1.072	1.074		1.079	1.081	1.078	
Sept. 1, 1971	1.098	1.095	1.099	1.097	1.077	1.078	1.080	1.078	1.098	1.093	1.097	1.096
Aug. 16, 1972	1.085	1.086	1.088	1.086	1.071	0.070	1.072	1.071	1.086	1.084	1.086	1.085
Aug. 9, 1973	1.082	1.082	1.079	1.081	1.070	1.071	1.071	1.071	1.078	1.078	1.077	1.078
Average	1.088	1.088	1.089		1.073	1.073	1.074		1.087	1.085	1.087	
Oct. 1, 1971	1.088	1.089	1.089	1.089	1.075	1.073	1.074	1.074	1.088	1.087	1.087	1.087
Sept. 25, 1972	1.081	1.080	1.082	1.081	1.067	1.069	1.071	1.069	1.083	1.086	1.085	1.085
Sept. 26, 1973	1.081	1.080	1.080	1.080	1.070	1.067	1.074	1.070	1.086	1.087	1.086	1.086
Average	1.083	1.083	1.084		1.071	1.070	1.073		1.086	1.087	1.086	

crop water use in each season from date of emergence to the dates of each harvest. Good agreement was obtained between estimated soil moisture deficits and the average measured deficits throughout each season. Figure 3 illustrates the agreement achieved in the 1973 season.

Relationships of total yields to estimated water use at each successive harvest date are plotted in Figures 4, 5 and 6 for the Norchip, Norland and Russet Burbank varieties, respectively. The yield data for these comparisons were averaged over all

spacings that were tested. Points in these figures do not include the 1971 data which were excluded due to suspected inaccuracies associated with the water use estimates.

Figures 4, 5 and 6 show convex relationships of yield to water use. The rate of yield increase per unit of water use diminishes as the season progresses or as harvest is delayed. The curvature of the yield versus water use relationship for the Norland variety increases more rapidly than for Norchip. The Russet Burbank curve in Figure 6

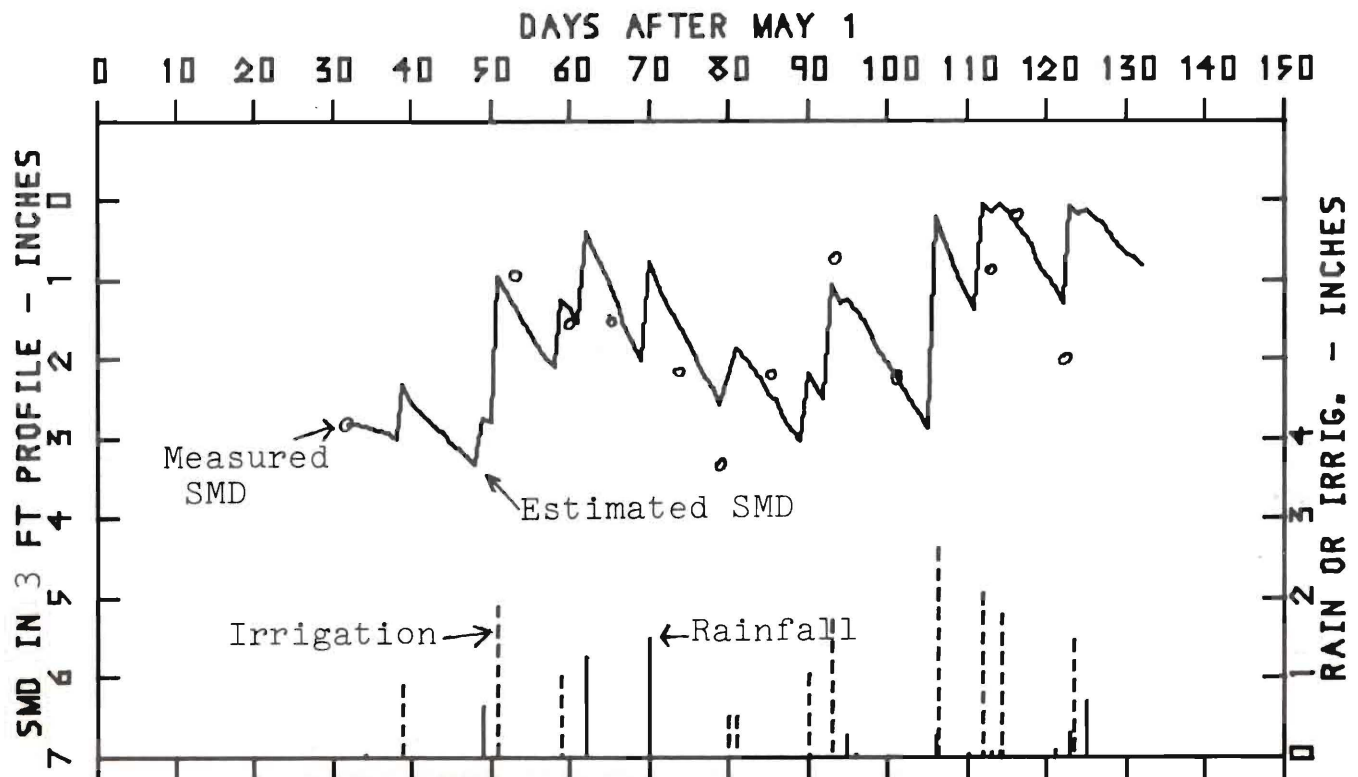


Figure 3. Measured versus estimated soil moisture deficits in the potato plot area in 1973.

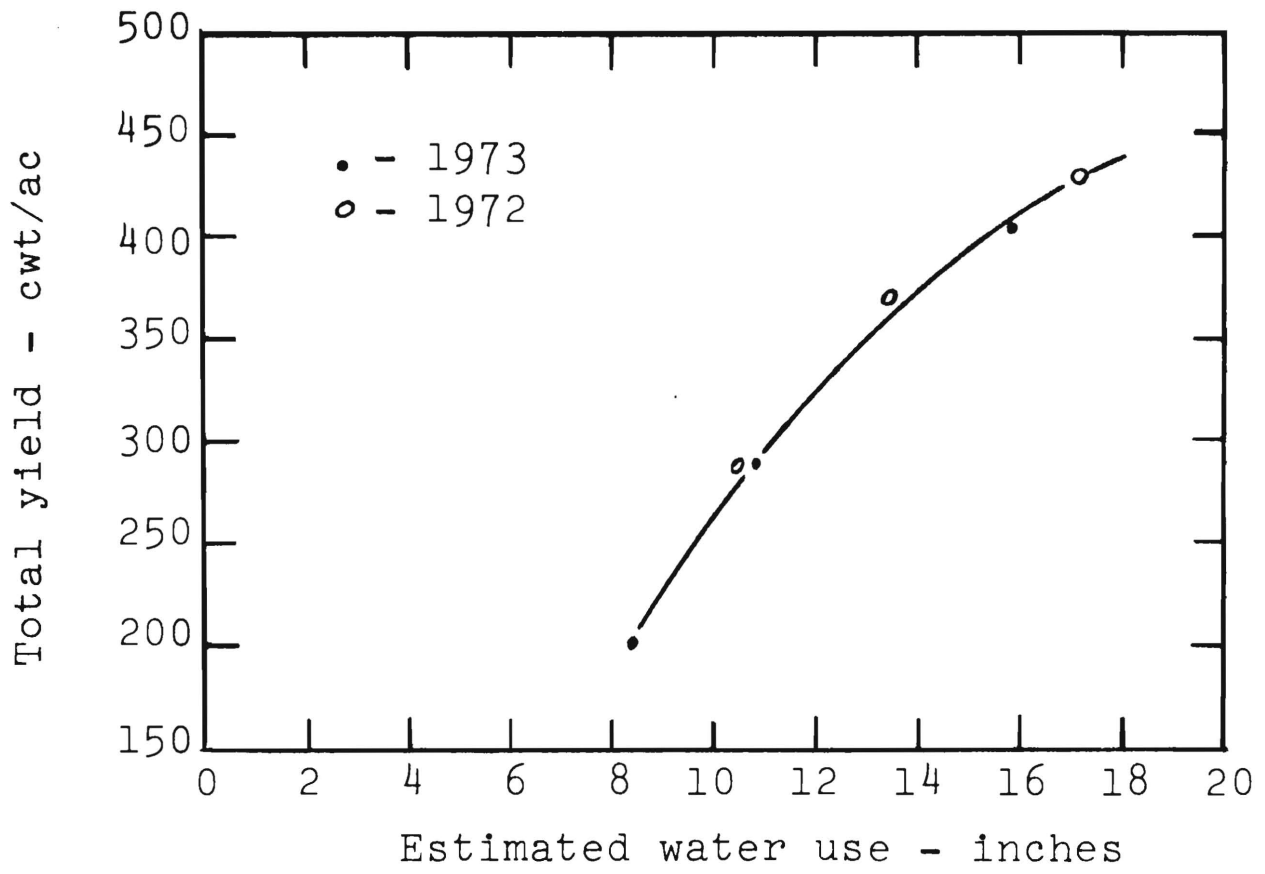


Figure 4. Relationship of Norchip total yield to estimated water use from emergence to date of harvest. Points in each season are data for three consecutive harvest dates.

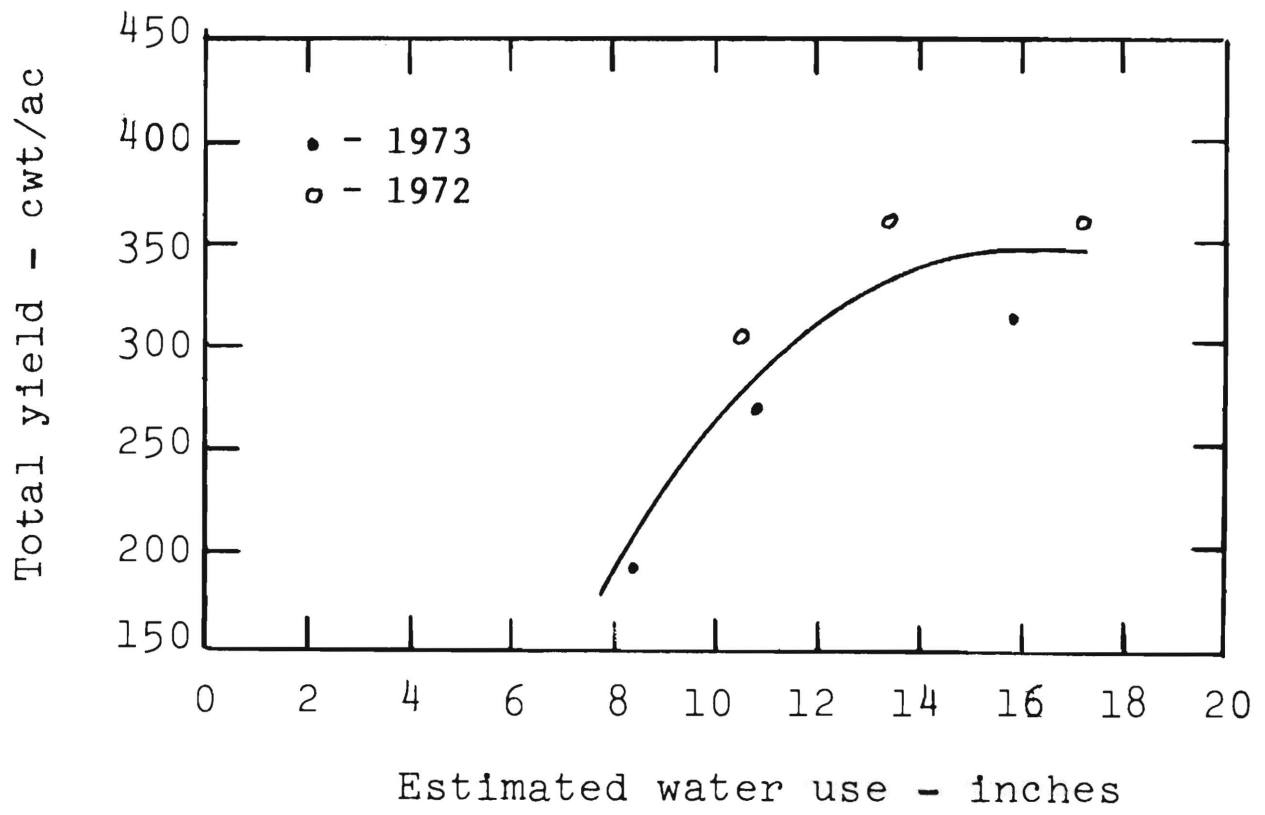


Figure 5. Relationship of Norland yield to estimated water use from emergence to date of harvest. Points in each season are data for three consecutive harvest dates.

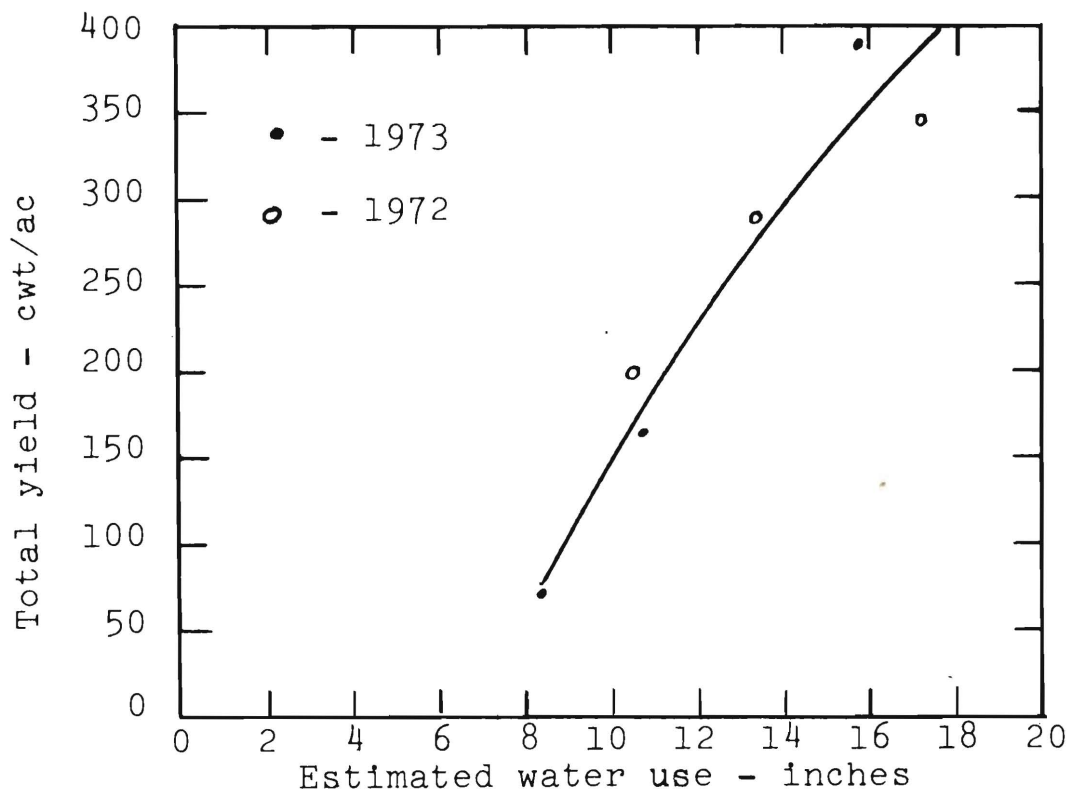


Figure 6. Relationship of Russet Burbank yield to estimated water use from emergence to date of harvest. Points in each season are data for three consecutive harvest dates.

is nearly linear, indicating that the rate of production per unit of water diminished very little in the latter part of the growing season.

The earlier maturing Norland and Norchip varieties produced more early yield with less water use than the Burbank variety. Seasonal water use from emergence to near peak production ranged from about 15 to 18 inches for the Norland versus the Burbank variety. The first 200 cwt/acre was produced at about 8 to 9 inches of water use after emergence for the Norland and Norchip varieties. The later Russet Burbank variety produced this yield level after about 11 inches of water use.

Maximum water use efficiency (production per unit of water use) occurs at the point where a line starting at the origin becomes tangent to each yield curve in Figures 4, 5 and 6. For the Norland variety the maximum water use efficiency (Figure 4) occurs near 13 inches of water use, which is accumulated by mid-August. For Norchip, the maximum efficiency occurs at about 16 inches of water use or near September 1. The maximum efficiency for the Russet Burbank variety apparently coincides with the season-ending killing frost.

### Summary

Three varieties of potatoes grown under irrigation at the Oakes site produced an average total yield of 392 and a marketable yield of 325 cwt/acre when harvested in late September or early October. The yields were appreciably affected by the variety grown and the plant spacing used. The highest total yield reached 484 cwt/acre, and the highest marketable yield was 401 cwt/acre during the three-year period. Early plantings of Norland and Norchip varieties yielded over 200 cwt/acre of marketable tubers by August 1. Seasonal water use from emergence to near peak production ranged from about 15 to 18 inches for the Norland versus the Russet Burbank variety. The first 200 cwt/acre was produced at about 8 to 9 inches of water use after emergence for the Norland and Norchip varieties. The later Russet Burbank variety produced this yield level after about 11 inches of water use.

### References

1. Bauer, Armand, D. K. Cassel and LeRoy Zimmerman. 1974. **Alfalfa Production Under Irrigation at Oakes, North Dakota**. N. Dak. Res. Rep. 47.
2. Stegman, E. C. and J. D. Valer. 1972. **Irrigation scheduling by computational methods: crop data and evaluations in North Dakota**. N. Dak. Res. Rep. 41.