well-wintered cows than from the low-wintered cows. The larger steers at weaning gained about 5 pounds more between weaning and slaughter than did the lighter weaned steers.

When home raised feed is available, we recommend wintering cows on a full maintenance ration of about 30 pounds of corn silage and 10 pounds of hay, or the equivalent in other combinations. However, if feed is scarce and abnormally high in price, we believe a stockman can safely winter his cows on 75 percent of the above daily rations for at least 3 winters without serious ill effects in the herd.

A WILLISTON EXPERIMENT STATION REPORT ON –

Potato Irrigation

• By Howard Olson and R. H. Johansen

Since 1941, potato variety trials have been grown under irrigation and dryland conditions at the Williston experiment stations. The irrigation station, established in 1939, is situated on the Lewis and Clark Irrigation project and the dryland station is 5 miles west of Williston on typical upland Williams soils. The dryland data were obtained from two different locations, as before 1955 the station was adjacent to Williston.

Precipitation is the main factor limiting crop yields in this area with a mean of 9.86 inches during the period of April to August.

The irrigated trials were conducted on soils of the Havre series ranging in texture from silty clay loam to silt loam typical of the Missouri river bottom. These soils are not particularly suitable for good potato production due to poor internal drainage, and poor physical condition when wet or dry. They do possess a high water holding capacity and tend to remain wet for considerable periods following irrigation or rainfall. This is an advantage in reducing the need for frequent water applications but it makes weed control difficult and discourages late season irrigation, for the soil remains too sticky for efficient operation of potato harvesting machinery.

Two types of irrigation studies with potatoes are reported here. One has been a continuous evaluation of potato varieties and selections from the Horticulture Department, North Dakota Agricultural Experiment Station at Fargo, when grown under irrigation and under dryland conditions. The other was an irrigation water requirement study carried out over a 6-year period (1948-1953) to determine when and how much to irrigate potatoes on Missouri river bottom soils.

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Performance of Potato Varieties Under Irrigation

The amount and distribution of rain-

fall during the growing season determined the irrigation schedule. The prospect of rain was also an important factor. Irrigation was sometimes delayed to minimize the hazard of excessive water which generally occurs when heavy rainfall follows irrigation. Excessive water on land with good surface and subsoil drainage is not serious, but on these soils water-logging occurs readily and is a constant hazard.

During the 14-year irrigation period, the potato trials under irrigation received 31 water applications. One application was made in 3 of the years, 2 in 5 of the years and 3 times in 6 of the years. The potatoes were irrigated 13 times in July, 9 in August, 7 in June and 2 times in May. Frequently a final irrigation, even when needed, was intentionally omitted to provide proper harvesting conditions.

Land preparation before planting included fall plowing, with cultivation and levelling in the spring. This practice of spring cultivation and levelling frequently dried out the soil sufficiently to delay emergence of potatoes unless irrigation or rainfall followed planting. Consequently, during the past 3 years (1955-1957), the land was levelled and irrigated in the fall and received a light harrowing in the spring.

No fertilizers were used in these trials prior to 1953 but since then sideband applications at planting time were made annually. Application rates varied from 200 to 350 pounds per acre of 33.5-0-0 or 20-20-0, depending on the previous history of the field. These rates were calculated to maintain high or maximum levels of fertility and may not have been the most economical.

The potato variety trials grown under irrigation and under dryland conditions were planted in blocks of 4 replicates with 25 plants of each variety per block. Although there were variations, the average spacing was 38 inches between rows and 14 to 15 inches in the row. The average planting date was May 19, but the trial was planted as early as May 7 and as late as June 5. Generally, the trials were harvested in the latter part of September. The harvested potatoes were weighed, graded and determinations were made for total yield, marketable yield, specific gravity and general quality. Tuber maturity and scab readings were also recorded in some years.

Although these variety trials were carried out for 14 years, for all practical purposes only the variety trial data recorded from 1950 through 1957 were considered, and only for those varieties or selections that were included in the trials for 3 or more years.

Table 1 shows the total yields in bushels per acre of 11 varieties and selections grown under irrigation and under dryland conditions in the 8 years 1950-1957. In comparing the 8 year average of irrigated versus dryland total yields, irrigation resulted in an increase of 191.3 bushels, or 56 percent, over the dryland yields. The average increase in any year varied from 301.3 bushels per acre in 1956 to 22.6 bushels per acre in 1950. The smallest differences occurred in years of above normal precipitation (1950, 1952 and 1954). All dryland production was on land that was summerfallowed the previous year. Therefore, twice the acreage was required to produce the dryland yields.

All varieties did not respond to irrigation in the same way. Of the varieties grown in these trials for 6 or more years, Early Gem showed the best response with an average increase in total yield of 276

Table 1. TOTAL YIELD IN BUSHELS PER ACRE OF POTATO VARIETIES GROWN UNDER IRRIGATION AND NON-IRRIGATION AT WILLISTON

Variety	1950		1951		1952		1953		1954		1955		1956		1957		Average	
	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.
Irish Cobbler	321	288	283	131	342	277	455	188	602	259					469	162	412	218
Red Pontiac	436	360	381	149	426	377	464	263	562	344	513	202	727	344	408	201	490	280
Early Gem			293	112	380	253	447	164	499	210	378	143	532	177	664	205	456	181
Norland											457	199	574	278	381	227	471	235
Nordak									575	240			518	265	359	170	484	215
Norgleam									574	269	474	181	501	246	351	164	475	215
Triumph	329	334	271	146	392	285	369	201	536	280	378	189	538	272			402	243
Kennebec	441	487	373	146	429	361											414	331
Redkote					386	330	369	201	455	316							403	281
ND 457-1	371	316	302	122	307	248	389	190									342	219
Manota					353	280	386	197	544	236	392	164			214	147	378	205
Average	380	357	317	134	377	301	411	201	463	349	432	180	565	264	407	182	430	238

I.—Irrigated. N.I.—Non-Irrigated.

Table 2. SPECIFIC GRAVITY OF POTATO VARIETIES GROWN UNDER IRRIGATION AND NON-IRRIGATION AT WILLISTON.

Variety	1950		1951		1952		1953		1954		1955		1956		1957		Average	
	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.	I.	N.I.
Irish Cobbler	96	102	83	82	88	90	94	94	81	80					83	99	86	89
Red Pontiac	89	83	78	60	81	69	84	91	70	71	72	69	75	86	65	80	75	75
Early Gem			77	69	86	77	84	85	76	74	75	68	79	79	76	87	79	77
Norland											79	77	77	83	68	84	75	81
Nordak									74	85			83	89	77	96	78	90
Norgleam									71	85	81	82	84	85	77	96	78	87
Triumph	92	93	75	70	84	80	84	91	74	83	77	74	76	84			78	80
Kennebec	97	88	79	58	86	78											83	68
Redkote					82	71	91	93	80	75							84	80
ND 457-1	101	97	87	81	90	87	96	98									91	89
Manota					90	89	87	95	77	82	86	80			69	92	82	88
Average	95	93	80	70	86	80	89	92	75	79	78	75	79	84	74	91	82	83

I.—Irrigated. N.I.—Non-Irrigated.
First 2 digits in specific gravity readings were dropped. For example 89 would read 1.089.

bushels per acre, as compared with Red Pontiac with an average increase of 209 bushels per acre.

It can also be seen (Table 1) that early maturing varieties generally showed better responses to irrigation than late maturing varieties. Early maturing varieties form and develop most of their tubers during July and August as compared with August and September for late maturing varieties. Since water applications were made most frequently in July and August, this period appears critical, particularly with early maturing varieties.

When fertilizer was first applied to the irrigation trials in 1953 and continued through 1957 a marked increase in yield was noted during this period. The average yield under irrigation without fertilizer (1950-52) was 358 bushels per acre, compared with 456 bushels per acre in the period 1953-57 when fertilizers were used.

Specific gravity is a convenient measure of solid or dry matter content of potatoes and is usually associated with texture or mealiness of the potato.

The 8-year average specific gravity of potato varieties and selections grown under irrigation and under dryland conditions at Williston was 1.082 and 1.083, respectively (Table 2). This was not significant, but great differences between years and between varieties did occur. The use of fertilizer in the irrigated plots during the period 1953 to 1957 resulted in decreases in specific gravity, as compared with that in irrigated plots with no fertilizer before 1953.

The variety Irish Cobbler showed the least variation within years in specific gravity when grown under irrigation or dryland conditions. Relatively small differences occurred with Early Gem, Triumph, Nordak and Norgleam. The 8-year average specific gravity for Red Pontiac was the same under irrigation and dryland conditions, but much variation occurred within years.

When potatoes were irrigated late in the season, maturity was delayed, causing immature skin and poor quality tubers. The number of rough and oversize tubers was also increased. However, late fall irrigation of land to be cropped to potatoes was beneficial to the crop the following year. This may not be as significant on coarser textured soils with lower water holding capacity.

Water Requirement Studies for Potatoes

Studies were carried out 6 years (1948-1953) to determine the frequency and amount of irrigation water required by potatoes grown on the Missouri river bottoms. The Pontiac variety was used in each year, except in 1948 when Cobbler was used. Fertilizers used were 350 pounds per acre of 0-45-0 in the years 1949-1951 and 425 pounds per acre of 10-32-0 in 1952 and 1953. No fertilizer was used in 1948.

Three different moisture levels were established. The low moisture plots were to receive only enough water to establish a stand; the medium moisture plots to receive 1 irrigation during the season and the high moisture plots to receive 2 or more irrigations depending upon the season.

Yield data showed good correlation between the amount of irrigation water applied and the total yield (Table 3). The high moisture plots produced the highest average total yield for the 6 years with 457 bushels per acre. The low moisture plots received irrigation water in 1952

and 1953 only, yet the mean yield was relatively high with 365 bushels per acre. Since the whole plot area was fall irrigated, it is apparent that the available moisture in the root zones was at a sufficiently high level during the following crop season to maintain reasonable plant growth.

Precipitation was also a factor, since in 2 of the 6 years this was above normal. Although irrigation during the growing season did result in increased yields, the factor of stored soil moisture makes it difficult to appraise the true value of seasonal irrigation on potato production.

Table 3. THE EFFECT OF MOISTURE LEVELS ON POTATO PRODUCTION AT WILLISTON IRRIGATION STATION (AVERAGE OF 6 YEARS).

	Mean Annual Precipitation (Inches)	Precipitation During Growing Season (Inches)	Irrigation Water Applied (Inches)	Irrigation and Precipitation (Inches)	Total yield*	U. S. No. 1 yield
Low moisture level	14.2	9.3	.8	10.1	365	295
Medium moisture level	14.2	9.3	4.4	13.7	403	332
High moisture level	14.2	9.3	9.2	18.5	457	378

*Yield in bushels per acre.