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The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Report of

Potato Investigations

By the United States Department of Agriculture at the Greeley, Colorado, Experiment Station in Cooperation with the County Commissioners of Weld County and the Colorado Agricultural Experiment Station

By CHARLES F. CLARK
Horticulturist

View of experimental plats with the station buildings in the background

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Report of

Potato Investigations

By CHARLES F. CLARK*
Horticulturist

INTRODUCTION

The Colorado Potato Experiment Station, which is located at Greeley, Colorado, was established in 1915 for the purpose of conducting "experiments to improve the potato industry of Colorado, for investigating the nature and causes of the potato disease prevalent in the state of Colorado and for finding remedial or preventive measures therefor, for studying cultural and crop rotation factors in their relation to potato production, for introducing and developing new and improved varieties of potatoes, and for conducting other studies for the benefit of the potato industry."†

The work of the station is conducted by the United States Department of Agriculture. Cooperating with the Federal Government are Weld county, which, thru the County Commissioners, has furnished the land and laboratory building, and the state of Colorado, which has furnished funds, disbursed thru the State Agricultural College, for equipment. The general supervision of the station, together with the potato investigations, exclusive of those which relate to diseases, are under the direction of the office of Horticultural and Pomological Investigations. The pathological work is conducted by the office of Cotton, Truck and Forage Crop Disease Investigations. Insect investigations have recently been started by the Bureau of Entomology.

SOIL, ROTATION AND [illegible]

The type of soil on which the station [illegible] heavy clay loam designated as the [illegible] the farm which is devoted to the potato experiments a four-year rotation is maintained which consists of potatoes one year, grain one year and alfalfa two years. Lack of space does not permit a longer period in alfalfa which would be desirable. The alfalfa ground

*Office of Horticultural and Pomological Investigations, Bureau Plant Industry, U. S. Department of Agriculture.
†Extract from terms of lease, March 13, 1915.
‡Field Operations of the Bureau of Soils, 1904.

which is to be planted to potatoes the following year is plowed shallow, or "crowned," late in the fall. In the spring the soil is pulverized by harrowing as early as moisture conditions will permit. In April or the first of May, the land is manured and plowed to a depth of eight or nine inches after which it is harrowed and leveled.

Practically all the potatoes used for seed are treated before planting, using a solution of corrosive sublimate containing one pound of the chemical to 120 gallons of water. Planting is started from the first to the fifth of June, the two-man type of planter being used for the machine work. Cultivation is begun as soon as planting is finished and continued until the vines become too large for further operations with the cultivator. With the exception of special irrigation experiments and a few non-irrigated rows the potatoes are irrigated at such times as their appearance and the condition of the soil would indicate that water was needed, the time for starting and the frequency of application depending upon climatic conditions. On the experimental plats the water is distributed by means of wooden tubes having an orifice of one inch in diameter which are placed in the ditch bank, one tube to each row. This system greatly facilitates the uniform application of water which is essential for accurate experimental work.

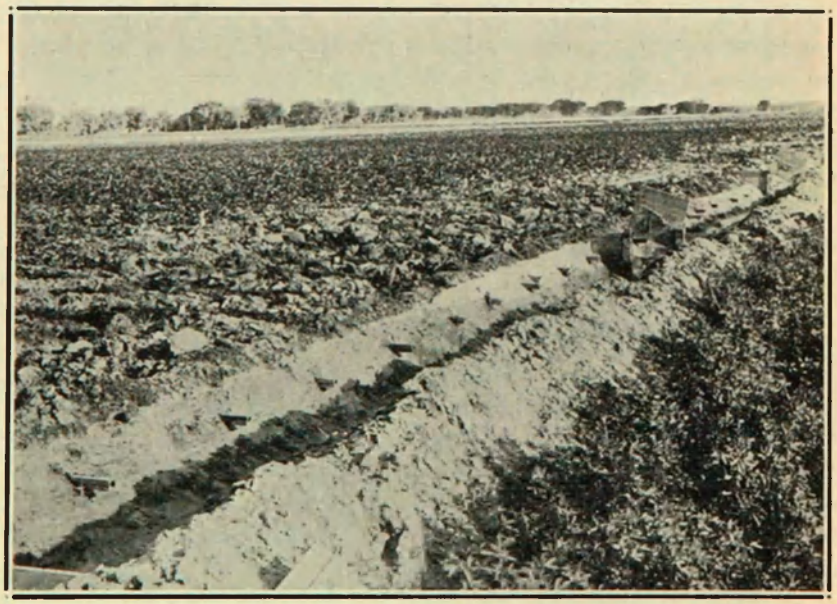

Fig. 1—Irrigation system used on experimental plats, showing tubes placed in ditch bank to secure a uniform distribution of water.

EXPERIMENTS

While the work of the station has been in progress for four seasons some of the experiments have not been conducted during the entire period, therefore it will be impossible in many cases to draw definite conclusions, which can be reached only after a long series of investigations under a comparatively wide range of climatic conditions. It is believed, however, that the results obtained up to the present time will be of value in pointing out the nature and scope of the work, the progress that has been made and tentative conclusions, if any, which may be drawn.

VARIETY TESTS

The area unit adopted for these tests was a four-row plat 240 feet long in 1915, 1916 and 1917, and 246 feet long in 1918. All tests were duplicated, the second series being planted as soon as the planting of the first series was completed. In 1915 seed of most of the varieties was obtained from two sources and planted side by side for comparison. In 1916 and subsequent years, purchased seed was compared with that which had been grown at the station one or more years. As this phase of the work increased from year to year it was necessary to gradually eliminate the varieties of least importance in the district because of lack of space.

The field weights were obtained as the crop was hauled into the storage cellar. After weighing, the potatoes were stored either in sacks or emptied in bins, the product of each plat being kept separate except that lots from corresponding plats of the two series were put together. During the winter they were graded by means of a sorter of the shaker type having a screen with one and seven-eighths inch meshes, those going over the screen being designated as marketable and those going thru as culls. The difference between the field weights and cellar weights after sorting, including both marketable and culls, constitutes the loss during storage.

In cases where seed was saved for the next season's planting it was picked out at the time of sorting. The badly diseased hills, however, especially those seriously effected by Rhizoctonia or Fusarium, were dug by hand and discarded early in the fall before the vines were damaged by frost but after the tubers had nearly completed their growth. The weights of these hills were recorded and added to the field weights obtained at the time the main crop was dug. Since these hills were discarded and not included in the

TABLE 1

Variety Test, 1915

VARIETY	Source of seed	Yield per acre, field weights			Weights after sorting total yield of series 1 and 2			Field weights, Series 1 and 2	Loss	Marketable
		Series 1	Series 2	Average	Marketable	Culls	Total			
		Bushels	Bushels	Bushels	Pounds	Pounds	Pounds	Pounds	Per cent	Per cent
Pearl	Colorado, irrigated	217.8	306.8	262.3	2,085	400	2,485	2,781	10.6	83.9
Pearl	Colorado, dry land	345.1	374.3	359.7	2,408	276	2,684	2,854	6.0	89.7
Pearl	Wisconsin	330.0	375.3	352.7	2,325	214	2,539	2,798	9.3	91.6
Peoples	Colorado	305.5	336.3	320.9	2,191	198	2,389	2,546	6.2	91.7
Peoples	Idaho	287.6	303.5	295.6	2,028	200	2,228	2,345	5.0	91.0
Rural New Yorker	Colorado	334.5	336.8	335.7	2,375	136	2,511	2,663	5.7	94.6
Rural New Yorker	Wisconsin	289.9	310.1	300.0	2,049	140	2,189	2,380	8.0	93.6
Green Mountain	Minnesota	366.0	335.5	350.8	2,344	203	2,547	2,783	8.5	92.0
Green Mountain	Wisconsin	409.9	432.8	421.4	2,912	243	3,155	3,343	5.6	92.3
Charles Downing	Colorado	252.3	256.4	254.4	1,778	123	1,901	2,018	5.8	93.5
Charles Downing	Idaho	288.4	275.3	281.9	1,651	475	2,126	2,236	4.9	77.7
Early Ohio	Minnesota	153.8	108.1	131.0	764	179	943	1,039	9.2	81.0
Late Ohio	Colorado	265.9	303.8	284.9	1,708	371	2,079	2,260	8.0	82.2
Irish Cobbler	Minnesota	217.8	193.1	205.5	1,301	222	1,523	1,630	6.6	85.4
Irish Cobbler	Wisconsin	239.0	257.6	248.3	1,604	250	1,854	1,970	5.9	86.5
Peachblow	Colorado	384.7	401.3	393.0	2,550	326	2,876	3,118	7.8	88.7
Russet Burbank	Colorado	343.6	336.8	340.2	2,157	317	2,474	2,699	8.3	87.2
Russet Burbank	Idaho	361.0	347.6	354.3	2,314	347	2,661	2,811	5.3	87.0
Garnet Chili[1]	Maine	272.2	274.3	273.3	924	82	1,006	1,084	7.2	91.8
Averages		298.2	308.7	303.5	1,972	248	2,220	2,387	7.0	88.5

[1]Each plat of this variety consisted of only two rows.

cellar weights they were deducted from the total field weights before calculating the loss during storage. The yields of the different varieties, both before and after sorting, as well as the losses during storage and the per cent of marketable tubers, for the years 1915 to 1918 inclusive, are given in tables 1 to 4.

In determining the merits of the different varieties for commercial production a number of features must be considered. While a good yield is essential it is equally important that tubers of good shape and cooking quality be produced and that the variety be sufficiently resistant to diseases to prevent rapid deterioration. In 1915, the year in which the greatest number of varieties was grown, the largest yield was obtained from the Green Mountain plats which were grown from the Wisconsin seed. The tubers, however, were of such inferior shape as to be scarcely fit for market. While the Peachblow ranked next in yield the large tubers of this variety showed the objectionable feature of cracking open during the process of growth. In 1916 this variety, grown from seed produced at the station the preceding year, showed a decided falling off in yield which was attributed largely to so-called "running out" as the result of pathological troubles. Altho fairly good yields have been obtained from the Russet Burbank, the tendency which this variety possesses of producing a second growth, or "knobbed" tubers, renders it undesirable for conditions which obtain at the station. While the three varieties mentioned above produce good crops of excellent quality in localities to which they are adapted, they are apparently

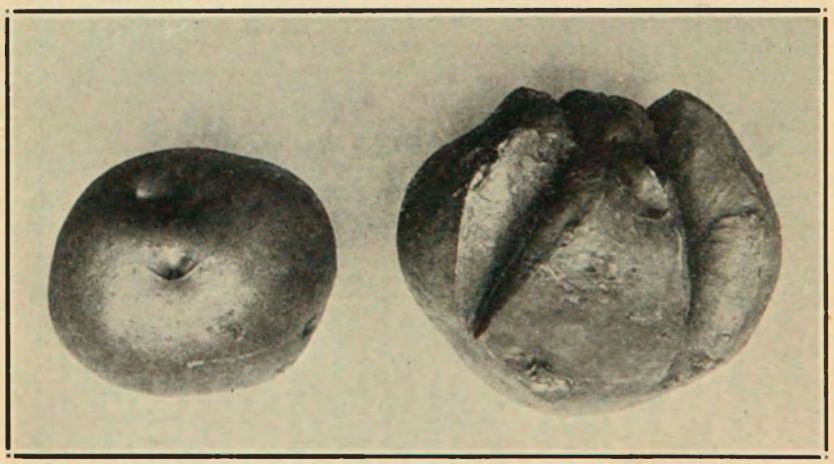

Fig. 2—Tubers of the Peachblow variety: left, good type of tuber grown under favorable conditions; right, cracked tuber, a type frequently found in the larger sizes when grown under conditions unsuited to this variety.

TABLE 2

Variety Test, 1916

VARIETY	Source of seed	Year first grown at station	Yield per acre, field weights			Weights after sorting, total yield of series 1 and 2			Field weights, Series 1 and 2	Loss	Marketable
			Series 1	Series 2	Average	Marketable	Culls	Total			
			Bushels	Bushels	Bushels	Pounds	Pounds	Pounds	Pounds	Per cent	Per cent
Pearl	Colorado, irrigated	1916	295.9	282.8	289.4	1,619	140	1,759	2,296	23.4	92.0
Pearl	Colorado, irrigated	1915	354.4	325.4	339.9	2,096	190	2,286	2,697	15.2	91.7
Pearl	Colorado, dry land	1916	371.1	289.9	330.5	2,088	172	2,260	2,622	13.8	92.4
Pearl	Colorado, dry land	1915	362.7	314.1	338.4	2,106	189	2,295	2,685	14.5	91.8
Pearl	Wisconsin	1916	364.0	329.0	346.5	2,186	176	2,362	2,749	14.1	92.5
Pearl	Wisconsin	1915	332.0	309.1	320.6	2,026	205	2,231	2,543	12.3	90.8
Rural New Yorker	Colorado	1916	316.1	271.5	293.8	2,075	76	2,151	2,331	7.7	96.5
Rural New Yorker	Colorado	1915	337.8	310.8	324.3	2,270	127	2,397	2,573	6.8	94.7
Rural New Yorker	Wisconsin	1916	347.9	316.4	332.2	2,265	88	2,353	2,635	10.7	96.3
Rural New Yorker	Wisconsin	1915	310.3	268.5	289.4	2,031	70	2,101	2,296	8.5	96.7
Russet Rural	Michigan	1916	300.5	286.6	293.6	2,096	77	2,173	2,329	6.7	96.5
Charles Downing	Idaho	1916	283.3	292.4	287.9	1,792	443	2,235	2,284	2.1	80.2
Charles Downing	Idaho	1915	308.5	291.7	300.1	1,938	401	2,339	2,381	1.8	82.9
Early Ohio	Minnesota	1916	198.9	198.9	198.9	1,324	218	1,542	1,578	2.3	85.9
Early Ohio	Minnesota	1915	249.8	258.4	254.1	1,671	299	1,970	2,016	2.3	84.8
Late Ohio	Colorado	1916	302.0	285.6	293.8	1,889	394	2,283	2,331	2.1	82.7
Late Ohio	Colorado	1915	317.1	306.8	312.0	2,027	391	2,418	2,475	2.3	83.8
Irish Cobbler	Wisconsin	1916	310.3	296.7	303.5	2,233	146	2,379	2,408	1.2	93.9
Irish Cobbler	Wisconsin	1915	315.9	300.2	308.1	2,166	192	2,358	2,444	3.5	91.9
Peachblow	Colorado	1915	290.9	209.2	250.1	1,742	165	1,907	1,984	3.9	91.3
Russet Burbank	Idaho	1916	295.2	224.6	259.9	1,428	447	1,875	2,062	9.1	76.2
Russet Burbank	Idaho	1915	323.9	241.2	282.6	1,646	415	2,061	2,242	8.1	79.9
Averages			313.1	282.3	297.7	1,942	228	2,170	2,362	7.8	89.3

TABLE 3

Variety Test, 1917

VARIETY	Source of seed	Year first grown at station	Yield per acre, field weights			Weights after sorting, total yield of series 1 and 2			Field weights, Series 1 and 2	Loss	Marketable
			Series 1	Series 2	Average	Marketable	Culls	Total			
			Bushels	Bushels	Bushels	Pounds	Pounds	Pounds	Pounds	Per cent	Per cent
Pearl	Colorado, irrigated	1917	364.0	369.5	366.8	2,199	276	2,475	2,910	14.9	88.8
Pearl	Colorado, irrigated	1916	355.9	321.9	338.9	1,986	293	2,279	2,689	15.2	87.1
Pearl	Colorado, irrigated	1915	362.0	350.6	356.3	2,119	317	2,436	2,827	13.8	87.0
Pearl	Colorado, dry land	1917	434.6	427.3	431.0	2,907	240	3,147	3,419	8.0	92.4
Pearl	Colorado, dry land	1916	371.6	365.5	368.6	2,313	295	2,608	2,924	10.8	88.7
Pearl	Colorado, dry land	1915	353.9	331.5	342.7	2,024	228	2,252	2,719	17.2	89.9
Pearl	Wisconsin	1917	402.6	428.3	415.5	2,731	295	3,026	3,296	8.2	90.3
Pearl	Wisconsin	1916	348.9	338.3	343.6	2,129	265	2,394	2,726	12.2	88.9
Pearl	Wisconsin	1915	338.8	339.3	339.1	2,096	262	2,358	2,690	12.3	88.9
Rural New Yorker	Colorado	1917	373.8	366.0	369.9	2,453	98	2,551	2,935	13.1	96.2
Rural New Yorker	Colorado	1916	402.3	386.9	394.6	2,797	70	2,867	3,131	8.4	97.6
Rural New Yorker	Colorado	1915	397.5	386.2	391.9	2,821	72	2,893	3,109	6.9	97.5
Rural New Yorker	Wisconsin	1917	413.4	397.5	405.5	2,859	67	2,926	3,217	9.0	97.7
Rural New Yorker	Wisconsin	1916	404.6	381.4	393.0	2,811	64	2,875	3,118	7.8	97.8
Rural New Yorker	Wisconsin	1915	395.8	376.6	386.2	2,804	66	2,870	3,064	6.3	97.7
Rural New Yorker	New York	1917	396.5	402.6	399.6	2,835	81	2,916	3,170	8.0	97.2
Russet Rural	Michigan	1917	387.2	376.4	381.8	2,714	92	2,806	3,029	7.4	96.7
Russet Rural	Michigan	1916	374.6	351.4	363.0	2,575	68	2,643	2,880	8.2	97.4
Charles Downing	Idaho	1915	261.9	279.1	270.5	1,932	194	2,126	2,146	.9	90.9
Late Ohio	Colorado	1915	312.1	302.5	307.3	2,120	296	2,416	2,438	.9	87.7
Irish Cobbler	Wisconsin	1917	282.1	297.5	289.8	2,116	150	2,266	2,299	1.4	93.4
Averages			368.3	360.8	364.6	2,445	180	2,625	2,892	9.1	92.8

TABLE 4

Variety Test, 1918

VARIETY	Source of seed	Year first grown at station	Yield per acre, field weights			Weights after sorting, total yield of series 1 and 2			Field weights, Series 1 and 2	Loss	Marketable
			Series 1	Series 2	Average	Marketable	Culls	Total			
			Bushels	Bushels	Bushels	Pounds	Pounds	Pounds	Pounds	Per cent	Per cent
Pearl	Colorado, irrigated	1918	322.3	366.5	344.4	4,691[1]	811	5,502	5,943	7.4	85.3
Pearl	Colorado, dry land	1918	388.9	384.3	386.6						
Pearl	Wisconsin	1918	317.8	337.5	327.7	2,079	312	2,391	2,552	6.3	87.0
Pearl	Wisconsin	1917	309.0	324.0	316.5	2,059	230	2,289	2,506	8.7	90.0
Pearl	Wisconsin	1916	283.6	305.3	294.5	1,858	226	2,084	2,304	9.5	89.2
Pearl	Wisconsin	1915	252.9	292.7	272.8	1,667	209	1,876	2,070	9.4	88.9
Rural New Yorker	Colorado	1918	240.6	282.9	261.8	1,688	158	1,846	1,946	5.1	91.4
Rural New Yorker	Colorado	1917	315.6	322.5	319.1	2,232	142	2,374	2,539	6.5	94.0
Rural New Yorker	Colorado	1916	315.9	332.8	324.4	2,149	163	2,312	2,595	10.9	93.0
Rural New Yorker	Colorado	1915	290.0	311.9	301.0	2,179	128	2,307	2,387	3.4	94.4
Rural New Yorker	Wisconsin	1918	283.4	312.9	298.2	3,928[1]	248	4,176	4,579	8.8	94.1
Rural New Yorker	New York	1918	283.6	292.5	288.1						
Averages			300.3	322.2	311.3	2,044	219	2,263	2,452	7.6	90.7

[1]Because of lack of storage space the crop from the seed from the different sources was not kept separate.

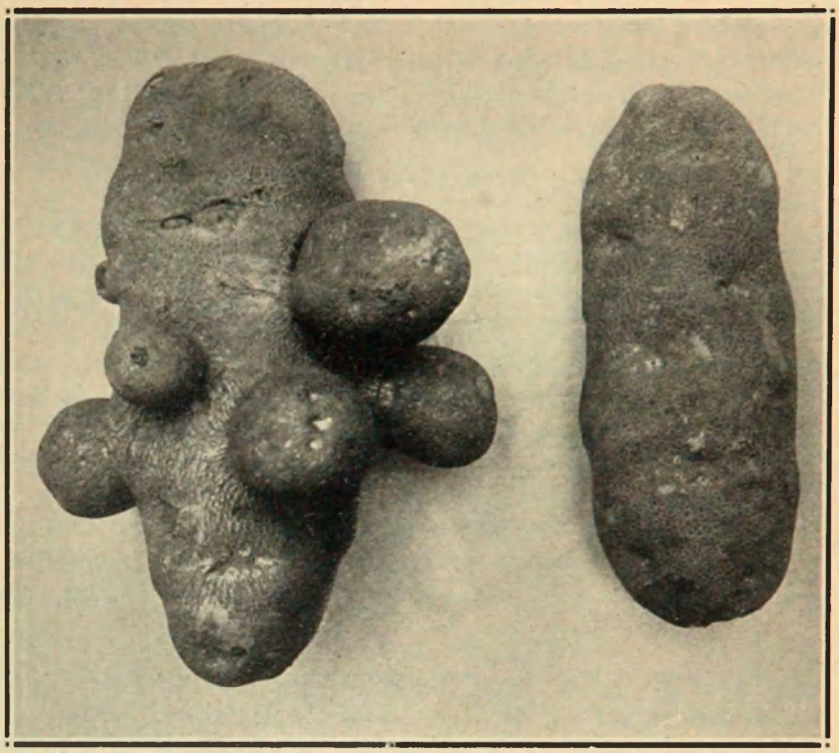

Fig. 3—Tubers of the Russet Burbank variety: right, good type of tuber grown under favorable conditions; left, undesirable type characteristic of this variety when grown on the heavier soils.

unsuited to conditions in the Greeley district. Of the varieties included in this test the Pearl and Rural New Yorker have given the most satisfactory results. While the total yields of the latter variety have in general been somewhat lower than those of the Pearl, this variety produces a much smoother type of tuber and a lower percentage of culls.

Comparing the three early varieties, Early Ohio, Irish Cobbler and Charles Downing, we find the yield of the Early Ohio considerably below that of the other two. This variety also has a tendency to produce rough, knobbed tubers under favorable conditions. On the other hand it ranks very high in cooking quality. The Irish Cobbler is apparently not suited to local conditions as the vines have invariably showed lack of vigor and the tubers elongated with very deep eyes. The Charles Downing produces tubers of good quality tho the percentage of culls is relatively high. The tubers of the Late Ohio appear to be identical with those of the Early Ohio.

This has led many to believe that the two names represent only a single variety. This is not the case as the Late Ohio produces a larger growth of vines differing in many respects from those of the Early Ohio, is later in maturing and produces a larger yield.

SOURCE OF SEED

With many of the varieties used in the variety test the seed was secured from two or more sources so that comparisons may be made which will show to some extent the relation of locality to quality of seed. The data bearing on this point are brot together in Table 5.

In 1915 there were three comparisons between Colorado irrigated and Idaho seed in two of which larger yields were obtained from seed from the last named source. The averages are also slightly in favor of the Idaho seed tho the differences are so small that they may be regarded as within the limits of error. The Irish Cobbler and Green Mountain varieties both produced larger yields from the Wisconsin seed than from that which was obtained from Minnesota. These comparisons are, however, few in number and for only

TABLE 5

Yields from Seed Obtained from Different Sources. Summarized from Tables 1, 2, 3 and 4. Bushels Per Acre, Field Weights.

VARIETY	Year of test	Source of seed					
		Colorado dry land	Colorado irrigated	Idaho	Minnesota	Wisconsin	New York
Peoples	1915	.....	320.9	295.6	.....	.....	.....
Green Mountain	1915	.....	.....	.....	350.8	421.4	.....
Charles Downing	1915	.....	254.4	281.9	.....	.....	.....
Irish Cobbler	1915	.....	.....	.....	205.5	248.3	.....
Russet Burbank	1915	.....	340.2	354.3	.....	.....	.....
Average		.....	305.2	310.6	278.2	334.9	.....
Pearl	1915	359.7	262.3	.....	.....	352.7	.....
Pearl	1916	330.5	289.4	.....	.....	346.5	.....
Pearl	1917	431.0	366.8	.....	.....	415.5	.....
Pearl	1918	386.6	344.4	.....	.....	327.7	.....
Average of Pearl		377.0	315.7	.....	.....	360.6	.....
Rural New Yorker	1915	.....	335.7	.....	.....	300.0	.....
Rural New Yorker	1916	.....	293.8	.....	.....	332.2	.....
Rural New Yorker	1917	.....	369.9	.....	.....	405.5	399.6
Rural New Yorker	1918	.....	261.8	.....	.....	298.2	288.1
Average of Rural New Yorker, 1915-1918			315.3	.....	.....	334.0	.....
Average of Rural New Yorker, 1917-1918			315.9	.....	.....	351.9	343.9

a single season. This does not eliminate the possible influence of seasonal variations on the original seed stock which may be reflected in the following crop.

The Pearl seed was obtained from three sources and the data cover a period of four years. With the exception of one season when the dry land seed was badly diseased, stock from this source has given the best results, with the Wisconsin seed next in order, the yields of both being considerably above those obtained from the Colorado irrigated seed. The largest yields of the Rural New Yorker were obtained from the Wisconsin stock, with yields from the New York state seed closely following. A study of the yields of all the varieties included in this experiment shows very consistently the relatively high quality, as measured by the crops produced, of the Colorado dry land and Wisconsin seed.

LOSSES DURING STORAGE

These losses, which are shown for the different years in next to the last column in tables 1, 2, 3, and 4, respectively, include the decrease in weight due to evaporation from the surface of the tubers and from respiration, also the weight of dirt which adhered to the tubers in digging but which was largely removed during the process of sorting. In 1917 severe freezes before all the potatoes

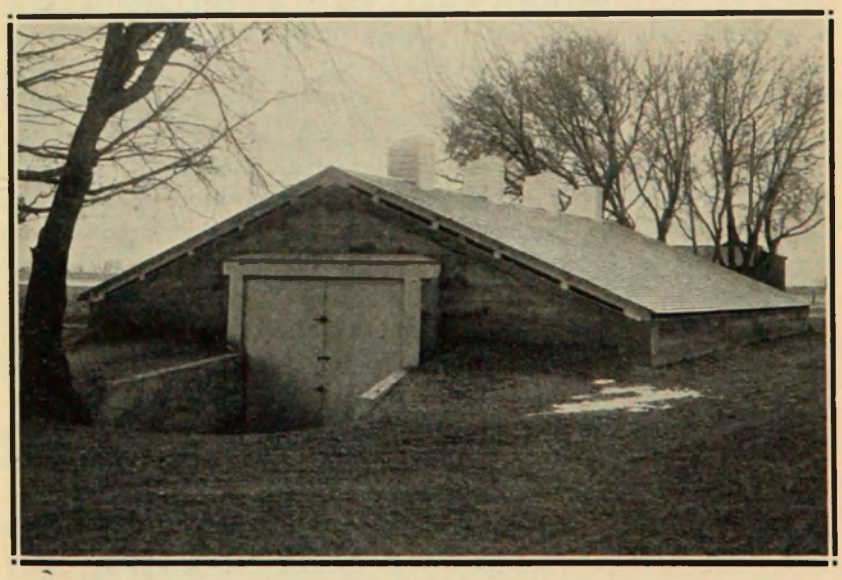

Fig. 4—Potato storage house at experiment station.

were dug caused some frost injury which resulted in losses in weight in addition to the sources enumerated above.

The potatoes were placed in the storage cellar and the field weights obtained the day on which they were dug. The sorting was done during the winter, usually between the middle of December and the middle of February, after which the cellar weights were recorded. As soon as the potatoes were placed in storage the temperature of the cellar was lowered as rapidly as possible until a uniform temperature slightly below 40 degrees F. was reached. The thermograph charts show that during the fall and winter seasons covered by the experiments a temperature range within the limits of 34 to 40 degrees F. was maintained from the last of November to the last of March. The relative humidity fluctuated between 80 and 90 per cent, depending upon the frequency of ventilation, except that for short periods when the ventilators were open, percentages below 60 were sometimes reached.

During the years 1915, 1916 and 1918, when there was practically no field frost, the average losses during the storage period were very uniform varying only from 7.0 to 7.8 per cent. The greater average loss in 1917, 9.1 per cent, is attributed largely to the effect of frost injury before digging in the case of some of the late varieties, particularly the Pearl. While the per cent of frosted tubers was comparatively small the loss in weight from those which were damaged was considerable. The wide variation in losses from the different varieties during a given season does not necessarily indicate that the magnitude of the loss may be a varietal characteristic tho the losses may be associated with certain relations of the variety to conditions. For example, the relatively small losses of the early varieties may be explained by the fact that they were dug early in the season, usually when the ground was dry so that practically no dirt adhered to them. The Pearl, as grown on the comparatively heavy soil of the station farm, produces a large percentage of knobbed tubers which carry more dirt into the cellar than the smooth tubers of the Rural New Yorker. In 1917 three of the varieties, Charles Downing, Late Ohio and Irish Cobbler, were not only almost entirely free from dirt when dug but were sorted and the cellar weights obtained the second day after digging thus affording little opportunity for loss from this source. On the other hand in 1916 the digging of the Pearl and Rural New Yorker was delayed by rains until it was so late that no time could be allowed for the ground to dry out, consequently the tubers and the soil adher-

ing to them were wet which resulted in relatively large losses in storage. Further evidence of the excessive shrinkage which follows the digging from wet soil is shown in the cooperative experiments at Carbondale where conditions obtained similar to those described above. The average loss from 900 bushels, including the Peachblow and Russet Burbank varieties, was 16.3 per cent.

To show the large amount of dirt that may be carried to the cellar on the tubers, the data which were obtained from the plats whose crop was stored in sacks have been brot together and the percentages determined. In these instances the potatoes, which were still in the sacks in which they were taken from the field, were weighed just before sorting. After sorting they were weighed again, the difference between the two weighings representing the amount of dirt which had been removed. The results are shown in Table 6.

TABLE 6

Storage Losses Due to Dirt Which Adhered to the Tubers at the Time of Digging.

Variety	Source of Data	Field Weights	Weight Before Sorting	Weight After Sorting	Total Loss During Storage	Loss Due to Dirt
		Pounds	Pounds	Pounds	Per Cent.	Per Cent.
Pearl	Variety test. New, 1-, 2- and 3-year old Wisconsin seed	9132	9089	8640	8.4	4.9
Pearl	Irrigation experiment. Early and late irrigated plats	5708	5514	5325	6.7	3.4
Rural New Yorker	Variety test. New and 1-year old Colorado seed	4485	4333	4220	5.9	2.6
Rural New Yorker	Irrigation experiment. Early and late irrigated plats	4855	4712	4545	6.4	3.5
Averages					6.9	3.6

Of the 24,480 pounds taken from the field representing the crop of two varieties from 20 plats, 918 pounds, or 3.6 per cent, was dirt, the weight of which constituted approximately one-half the total shrinkage. It should be borne in mind, however, that the amount of dirt which adheres to the tubers varies greatly with the variety, the character of the soil and its condition at the time of digging with respect to moisture.

In order to determine the internal losses of the tubers during

storage potatoes of the Rural New Yorker variety, which were practically free from dirt and which had been in the storage cellar for over a month, were placed in barrels where they remained undisturbed during the remainder of the storage period. The barrels were set on the dirt floor of the cellar. The tops of the barrels were covered with sacks. The temperature of the cellar was kept below 40° F. with the relative humidity ranging between 80 and 90 per cent. The weight on November 30, after being transferred to the barrels, was 2,097 pounds. On April 3 they were again weighed at which time a loss of 23 pounds, or 1.1 per cent, was recorded. Since they were surrounded by a comparatively moist atmosphere the surface evaporation was reduced to a minimum, therefore the losses may be attributed largely to respiration.

PER CENT OF MARKETABLE TUBERS

In order to compare the different varieties under experiment with respect to the proportion of marketable tubers which they produce, the weights from all plats of each variety in the variety test were summarized and the percentages determined. The results are shown in Table 7.

TABLE 7

Per Cent of Marketable Tubers. Computed from Weights of Marketable Tubers and Total Weights after Sorting in Tables 1, 2, 3 and 4

Variety	Years of Test	Number of Plats	Marketable Tubers
			Per Cent.
Pearl	1915–1918	48	89.3
Peoples	1915	4	91.4
Rural New Yorker	1915–1918	38	95.7
Russet Rural	1916–1917	6	96.9
Green Mountain	1915	4	92.2
Charles Downing	1915–1917	10	84.7
Early Ohio	1915–1916	6	84.4
Late Ohio	1915–1917	8	84.2
Irish Cobbler	1915–1917	10	90.8
Peachblow	1915–1916	4	89.7
Russet Burbank	1915–1916	8	72.2
Garnet Chili	1915	2	91.8

This table shows very clearly the varietal differences in the percentage of marketable tubers produced. The varieties which lead in this respect are the Rural New Yorker and the Russet Rural. These are closely related varieties belonging to the same group. The lowest percentage was obtained from the Russet Burbank. This was probably due in part to the fact that the tubers are compara-

tively long and slender, so it is probable that many tubers went thru the screen endwise which would have gone over if they had been round tubers of the same weight. In commercial grading it is customary to use a 1¾-inch screen for this variety. Comparing the four varieties which are most extensively grown in the Greeley district we find that the two late varieties, the Rural New Yorker and Pearl, rank considerably higher than the two early varieties, the Charles Downing and Early Ohio, in the percentage of marketable tubers with the first named variety exceeding the Pearl by 6.4 per cent.

RUNNING OUT OF VARIETIES

This experiment was conducted in connection with the variety test to determine if possible whether the productivity of a variety can be maintained for a period of years without change of seed. This phase of the work was started in 1915 with seed from 10 sources, representing seven varieties. Seed was saved from the crop produced by each lot and grown the following year in comparison with new seed which came from the same source from which the 1915 seed was obtained. In 1917 the new seed was compared with stock from the same original source which had been grown at the station one and two years, respectively, while in 1918 comparisons were obtained between new seed and 1-, 2- and 3-year-old seed, all from the same original source. Because of the increase in the number of plats from year to year it was necessary to gradually reduce the number of varieties because of lack of space until in 1918 there remained only two varieties, the Pearl from Wisconsin and the Rural New Yorker from Colorado. The results are shown in Table 8.

In 1916 larger yields were obtained from the station seed in eight of the ten trials, the average increase in yield over that produced by the new seed being 13.3 bushels. In the two instances where new seed produced larger yields the seed came from Wisconsin. In 1917 in four out of five trials the largest yields were produced by the new seed. The yields from the two-year-old seed were in general slightly lower than those obtained from seed which had been grown at the station but one year.

In 1918, the number of sources from which new seed was obtained was reduced to two, the Pearl from Wisconsin and the Rural New Yorker from Colorado. In the case of the Pearl there was a gradual decrease in yield corresponding with the length of

TABLE 8

Yields of Crops Grown in 1916, 1917 and 1918 from New Seed and from Seed Grown at the Station for 1, 2 and 3 Years, Respectively. Summarized from Tables 1, 2, 3 and 4

VARIETY	Original source of seed	Yield per acre, field weights (bushels). Crop of 1916, Year first grown at station			Crop of 1917, Year first grown at station			Crop of 1918, Year first grown at station			
		1916	1915	Difference	1917	1916	1915	1918	1917	1916	1915
Pearl	Colorado, irrigated	289.4	339.9	50.5	366.8	338.9	356.3	.....	.....	.....	.....
Pearl	Colorado, dry land	330.5	338.4	7.9	431.0	368.6	342.7	.....	.....	.....	.....
Pearl	Wisconsin	346.5	320.6	—25.9	415.5	343.6	339.1	327.7	316.5	294.5	272.8
Rural New Yorker	Colorado	293.8	324.3	30.5	369.9	394.6	391.9	261.8	319.1	324.4	301.0
Rural New Yorker	Wisconsin	332.2	289.4	—42.8	405.5	393.0	386.2	.....	.....	.....	.....
Charles Downing	Idaho	287.9	300.1	12.2	.....	.....	.....	.....	.....	.....	.....
Early Ohio	Minnesota	198.9	254.1	55.2	.....	.....	.....	.....	.....	.....	.....
Late Ohio	Colorado	293.8	312.0	18.2	.....	.....	.....	.....	.....	.....	.....
Irish Cobbler	Wisconsin	303.5	308.1	4.6	.....	.....	.....	.....	.....	.....	.....
Russet Burbank	Idaho	259.9	282.6	22.7	.....	.....	.....	.....	.....	.....	.....
Averages		293.6	307.0	13.3	397.7	367.7	363.2	.....	.....	.....	.....

time that the seed had been grown at the station. On the other hand the Rural New Yorker showed an increase in yield up to and including the third year and a decrease the fourth year, tho it should be noted that the yield of the 1915 seed was greater by 39.8 bushels per acre than that of the new seed. Whether the falling off in yield from the three-year-old seed indicates that a permanent degeneration has begun can be determined only by further experiments. The fact that the original stock from which this seed was obtained has been grown continuously in this locality without change of seed for approximately twenty years with no apparent signs of running out, suggests the improbability of any great deterioration in this variety so long as it can be kept free from certain diseases which tend to cause degeneration.

While the time covered by these experiments is not sufficient to settle the matter conclusively there are some deductions that can be made. One point of significance is the different behavior of the two varieties, which is readily explained. The Rural New Yorker plats showed very little evidence of disease, in fact this variety appears to be very nearly immune to the diseases which are considered as being responsible for one form of degeneracy. On the other hand the Pearl variety, with the exception of the plats grown from the new seed, was badly affected with Mosaic disease which appeared to increase in intensity with the length of time that the seed stock had been grown at the station. Accompanying this condition was a gradual diminution of yield from year to year. A similar instance of running out due to a diseased condition of the plants was observed in the Peachblow grown in 1916 from one-year-old seed. It is believed that the greater part of the running out of varieties which has been observed by growers in the West is largely due to the effect of certain of the so-called nonparasitic diseases, including Mosaic, Leaf-roll and possibly others. These diseases attack the vines thereby reducing the vigor of the plants and ultimately the yield. The shape of the tubers is not necessarily affected so that the diseased condition may not be apparent in the cellar tho in the advanced stages rough, elongated types are frequently found.

There is another type of running out which is occasionally found in individual hills which appears to be more strictly a physiological degeneration. In this case the condition is usually one of excessive vine growth which is apparently not associated with any disease, a heavy production of seed balls and with tubers of abnormal shape

with deep eyes. In the Greeley district this type has been observed most frequently in the Pearl variety. The abnormal tubers are usually pear-shaped with smooth, glossy skin which is generally tinged with pink, especially near the stem end. Experiments at the station have shown that the crop grown from these tubers is similar in character to that of the seed which was planted. So far it has been impossible to determine whether this condition was reached by successive stages or whether the transition from the normal type was sudden as in the case of mutations. While the pear-shaped type of tuber is characteristic of this form of degeneration it does not follow that all tubers of this type are run out, at least in certain varieties. For example, in 1918, tubers of this shape were selected from the Rural New Yorker and planted beside an equal number of tubers of the best type that could be found in the same lot of seed. The crop produced by the pear-shaped tubers was equally as good, both in regard to quantity and quality, as that produced by the good type of seed tubers.

Apparently in this case there was only a temporary modification of the individual tuber which was undoubtedly in some way effected by the nutrition of the plant during tuber formation and should not be considered a form of degeneration. These instances show that different varieties behave differently with respect to running out.

THE GREENING OF SEED

The variety used for this experiment was the Pearl. The seed was greened by spreading it out in a thin layer in trays and exposing it to strong light until the surface of the tubers had become thoroly greened. This required about two weeks. The spring greening was done in April and the fall greening the latter part of November. Short, thick sprouts were produced during the process of greening in the spring. Many of these were bruised or broken off in planting which was done with a machine. The yields and the increases or decreases resulting from greening are given in Table 9.

The results show that lower yields were produced by the seed which was greened in the fall than from that which had not been greened. It should be stated in this connection that the fall greening was very unsatisfactory. Because of the lack of strong light the greening at that time of the year was not as thoro as that which was done in spring; furthermore, there was some drying out

and shrinking of the tubers due to the fact that it was necessary to keep the room in which they were stored during the greening process, heated to prevent freezing.

Aside from conclusions which may be drawn from experimental results, fall greening is believed to be impractical under the conditions which obtain in this locality. Practically all of the seed used by the growers is either picked out from the main crop during the winter at the time of sorting or is bought in the spring so that the seed is not available in the fall for greening at that time. The low night temperatures in the fall after the late varieties are dug would necessitate the transfer of the potatoes to the storage house each night or specially constructed buildings would need to be provided to prevent freezing and at the same time admit sufficient light for greening. The short daily period of sunlight of relatively low intensity at that time of the year would greatly prolong the period required for thoro greening.

The seed greened in spring produced a larger yield than the ungreened seed in each of the three years of the experiment. The increases in 1917 and 1918, however, were so small as to be scarcely significant from the practical standpoint tho they are very consistent. In 1916, when the effect of greening was most pronounced, the plants from the greened seed came up about two days earlier than those from the ungreened seed and produced a more vigorous growth of vines during the early stages of growth. This difference

TABLE 9

Comparison of Yields from Greened and Ungreened Seed.

TREATMENT OF SEED	Crop of 1916 (bushels)		Crop of 1917 (bushels)		Crop of 1918 (bushels)	
	Yield per acre	Increase or decrease (—)	Yield per acre	Increase or decrease (—)	Yield per acre	Increase or decrease (—)
Check—seed not greened	....	....	426.0	....	....	....
Seed greened in fall	....	....	407.1	—6.1	....	....
Check—seed not greened	337.9	....	400.3	....	352.5	....
Seed greened in spring	371.7	24.8	407.6	2.6	351.5	4.5
Check—seed not greened	355.8	....	409.6	....	341.4	....
Seed greened in fall	....	....	403.3	—5.1	....	....
Check—seed not greened	....	....	407.1	....	....	....
Seed greened in spring	382.8	31.2	417.5	3.9	342.9	2.1
Check—seed not greened	347.0	....	420.0	....	340.2	....
Average increase resulting from spring greening		28.0	....	3.3	....	3.3
Average decrease resulting from fall greening	....	....	....	—5.6	....	....

could be detected for about six weeks. In 1917 the germination appeared to be hastened slightly by greening tho the differences in the rate of growth disappeared after a few days. In 1918 the effects of greening observed in previous years could not be discerned except in the small increase in yield.

IRRIGATION

Considerable difference of opinion exists among practical growers regarding the stage of growth at which irrigation should be started. Some maintain that water should not be applied until after the tubers have set even tho the plants have begun to suffer from lack of water. Others hold that if the plants show need of water at an earlier period it should be applied.

To determine, if possible, which of these views is correct experiments were conducted in 1917 and 1918 with two of the late varieties, the Pearl and Rural New Yorker. Each plat consisted of eight rows. In 1917, when only the Pearl variety was used, one-half of each plat was planted with dry land seed and the other half with Wisconsin seed. In 1918 Pearl seed from Wisconsin and Rural New Yorker seed from Colorado were used for the respective halves of each plat. To overcome any effects which might arise from lateral movement of water in the soil the plats were separated by two discard rows the yields of which are not included in the experimental data.

The different periods at which irrigation was started were designated as "checks," "early," "medium" and "late." On the check plats irrigation was started in 1917 just as the tubers were beginning to set. In 1918 tuber development was farther advanced at the time of the first irrigation which was delayed because of rains. The early irrigated plats received the first irrigation about two weeks before tuber formation had started. On the plats designated as "medium," which were employed only in 1917, the first application of water was on the same date as that of the check plats. The total number of irrigations for the season was, however, one less. On the late irrigated plats irrigation was not started until after the tubers had made considerable growth. At that time the dark color and stunted appearance of the plants plainly indicated the need of water. These plats received the same number of irrigations as the "medium" plats but the first application was much later. The results are given in Table 10. In addition to the yields per acre based on actual weights the corrected yields have been

TABLE 10

Results Showing Relation of Yield to Time of Starting Irrigation.

Crop of 1917

Plan of Experiment	Dates of Irrigation			YIELD PER ACRE (BUSHELS)					
				Pearl, Dry Land Seed			Pearl, Wisconsin Seed		
	July	August	September	Actual Yields	Corrected Yields	Increase or Decrease (-)	Actual Yields	Corrected Yields	Increase or Decrease (-)
Check	21	14, 23, 30	7	462.8	.....	.....	454.8	.....	.....
Early	9, 27	14, 23, 30	7	476.7	480.1	17.3	458.8	463.5	8.7
Late	..	14, 23, 30	7	417.7	424.6	-38.2	409.6	419.1	-35.7
Check	21	14, 23, 30	7	452.5	.....	.....	440 6	.....	.....
Medium	21	14, 23	7	438.4	436.5	-16.0	425.5	428.4	-12.2
Early	9, 27	14, 23, 30	7	465.6	461.7	9.2	444.4	450.3	9.7
Check	21	14, 23, 30	7	458.3	.....	.. ..	431.8	.....	.....
Late	..	14, 23, 30	7	417.9	427.6	-30.7	388.7	393.7	-38.1
Medium	21	14, 23	7	438.6	457.9	- .4	413.2	423.1	- 8.7
Check	21	14, 23, 30	7	429.3	.....	.....	416.9	.....	.....

TABLE 10—Continued

Crop of 1918

Plan of Experiment	Dates of Irrigation			YIELD PER ACRE (BUSHELS)					
				Pearl			Rural New Yorker		
	July	August	September	Actual Yields	Corrected Yields	Increase or Decrease (-)	Actual Yields	Corrected Yields	Increase or Decrease (-)
Check	..	11, 20, 29	.....	387.5	.....	.....	325.7	.....	.....
Early	6	8, 20, 29	.....	381.8	393.8	6.3	323.2	329.8	4.1
Late	..	20, 29	.....	314.1	338.1	-49.4	267.6	280.7	-45.0
Check	..	11, 20, 29	.....	351.5	.....	.....	306.0	.....	.....
Early	6	8, 20, 29	.....	379.8	372.2	20.7	322.3	312.5	6.5
Late	..	20, 29	.....	328.4	313.3	-38.2	281.2	261.7	-44.3
Check	..	11, 20, 29	.....	274.2	.....	.....	335.3	.....	.....

SUMMARY

Average of the two series. Increase or decrease over checks. (Bushels per acre.)

	Crop of 1917		Crop of 1918	
	Pearl Dry Land Seed	Pearl Wisconsin Seed	Pearl	Rural New Yorker
Early	13.3	9.2	13.5	5.3
Medium	- 8.2	-10.5	....	....
Late	-34.5	-36.9	-43.8	-44.7

included. These corrections, which are for the purpose of eliminating so far as possible differences in yield due to variability in the soil, are calculated by adding to the yield of the plat next in succession after a given check plat one-third the difference between the yields of the check plats on either side if the yield of the second check plat is lower than that of the first. If the larger yield is produced by the second check plat, then one-third the difference is subtracted. Two-thirds of the difference is added to or subtracted from the yield of the plat next in order. Each group of four plats, consisting of two plats receiving different treatments and the two check plats on either side, is treated independently. The corrected yields are then compared with the yields of the preceding check plat.

In all cases the largest yields were obtained from the early irrigated plats. Compared with the check plats the omission of one irrigation on the "medium" plats resulted in significant decreases in yield. On the "late" plats large decreases followed the withholding of water until late in the season. Comparing the yields of the medium and late irrigated plats, which received the same number of irrigations, but beginning earlier, we find that the yields of the former are substantially larger.

In 1918 the proportion of the tubers which were marketable was determined for each of the lots grown under the different conditions of irrigation. The results are shown in Table 11.

It was found that in the case of both of the varieties used for this experiment the largest percentages of marketable tubers were obtained from the plats which had received the early irrigations. In the Pearl the check plats were next in order while in the Rural New Yorker the per cent of marketable tubers on the check plats was slightly lower than that which was obtained from the late irrigated plats tho the difference is small and possibly within the limits of error. It was observed during the process of digging that the

TABLE 11

Effect of Time of Starting Irrigation on Percentage of Marketable Tubers. Summary of the Two Series for 1918.

PLATS	VARIETY	
	Pearl	Rural New Yorker
	Per Cent	Per Cent
Early	93.2	95.2
Checks	91.7	93.1
Late	90.5	94.0

tubers of the Pearl variety appeared to be a little smoother and freer from knots on the early irrigated plats than on the others. No difference was found in the quality of tubers produced on the different plats of the Rural New Yorker. It is characteristic of this variety, however, to produce smooth tubers under practically all conditions.

While the evidence thus far obtained is wholly in favor of the early beginning of irrigation further experiments under a wide range of climatic conditions and with a greater number of varieties are necessary before the question can be definitely settled.

SIZE OF SEED

These experiments, which were started in 1915 for the purpose of determining the most economical size of seed to use, are part of the general project of the United States Department of Agriculture for the study of this problem. In addition to the work along this line in Colorado similar experiments have been conducted at Jerome, Idaho; Presque Isle, Maine, and Norfolk, Virginia.

EXPERIMENTS AT GREELEY, COLORADO

The sizes of seed used for these experiments included 1-, 2-, 3-, 4-, 5-, and 6-ounce seed pieces. Since the work was carried on with both whole and cut tubers the studies also include comparisons between these two kinds of seed. The separation of the seed tubers into different sizes was performed by first roughly grading them with a sorter, using screens of different sizes. The final division was then made by weight, placing each tuber on a spring balance graduated in grams, allowing a variation of 5 grams on either side of the exact ounce equivalent, except that in the case of 8- and 12-ounce tubers a variation of 10 grams in either direction was allowed. Where cut seed was used the tubers which were halved were cut lengthwise, while the quartered tubers were first cut lengthwise then at right angles to the long axis, the four pieces being of approximately the same weight. In 1915, 1916 and 1917 the planting was done by hand. In 1918 a planter was used. The distance between hills was 14 inches in 1915 and 1918, and 16 inches in 1916 and 1917. The rows, in all cases, were 36 inches apart.

The separation of the tubers into the two grades, marketable and culls, was based on weight in 1915, 1916 and 1917, those weighing three ounces or more (over 85 grams) being classed as marketable while those which weighed less than three ounces were con-

sidered as culls. In the experiment of 1918, which was on a field basis, the grading was done with a sorter having a 1⅞-inch screen. With the Rural New Yorker variety this size of screen separates the tubers at approximately the three-ounce size. No tubers less than ½ inch in diameter were included.

Since the results will be published in detail in the complete report of the size of seed experiments, only parts of the summarized data which bring out some of the most prominent features will be included in this report.

EXPERIMENTS OF 1915

Because of the small amount of seed available, the experiment of this season was on a comparatively small scale. The number of hills planted was as follows: One-ounce whole, 120 hills; three-ounce whole, 120 hills; three-ounce halved, 240 hills; four-ounce whole and halved, 60 hills each. The series was planted without duplication. The variety used was the Irish Cobbler. The calculated yields per acre are based on the hills present at the time of digging, no allowance being made for missing hills. The results, which are given in the 4th, 7th, 10th and 14th columns of Table 12, show that the number and weight of tubers per hill before sorting, which includes both marketable and culls, very consistently increased as the size of the seed piece increased. This was true for both the whole seed and the seed cut in halves. The marketable tubers and the calculated yields per acre also showed increases in the same direction with the exception of the six-ounce seed cut in halves which produced a slightly lower yield than the four-ounce halved. The difference, however, is so small as to be considered within the limits of error.

EXPERIMENTS OF 1916-1917

Since identical plans were followed in carrying out the experiments of these two years the results will be discussed together. The entire series was planted in duplicate each year with ninety hills of each lot in each series. The variety used in these experiments was the Rural New Yorker. Since the seed was planted by hand in an open furrow the soil dried out somewhat during the process of planting so that the soil which was directly in contact with the seed pieces did not contain as much moisture as is usually the case where the planting is done with a machine. Furthermore there was considerable drying out of the soil with which the tubers were covered during the hot, dry period which followed planting. These conditions made the test a severe one and undoubtedly served

TABLE 12

Relation of Size of Seed Piece to Number of Stems, Number and Weight of Tubers Per Hill, and Per Cent and Yield Per Acre of Marketable Tubers.

SIZE OF TUBERS	Weight of Seed Piece Planted Ounces	No. of Stems per Hill Greeley '16 &'17	Number of Tubers per Hill			Weight of Tubers per Hill (Ounces)			MARKETABLE TUBERS							
									Per Cent. of Weight				Bushels per Acre			
			Greeley 1915	Greeley '16 &'17	Greeley 1918	Greeley 1915	Greeley '16 &'17	Greeley 1918	Greeley 1915	Greeley '16 &'17	Greeley 1918	Carbondale '16	Greeley 1915	Greeley '16 &'17	Greeley 1918	Carbondale '16
1 Ounce Whole	1	1.8	4.4	4.3	3.2	17.9	25.1	23.5	80.3	93.4	95.5	....	186.7	229.1	295.7	.....
2 Ounce Whole	2	2.6	...	6.3	4.0	....	30.9	26.5	....	90.7	93.6	90.0	....	293.0	332.1	413.2
3 Ounce Whole	3	3.2	6.9	7.2	4.9	25.6	31.3	27.1	77.4	88.1	90.8	86.9	248.0	275.0	316.8	453.9
4 Ounce Whole	4	3.7	7.7	8.0	...	28.2	33.6	....	80.1	85.9	....	85.5	292.1	287.5	.....	460.9
5 Ounce Whole	5	4.5	...	9.2	...	....	34.8	....	....	83.7	....	86.6	.....	299.1	.....	462.7
6 Ounce Whole	6	5.0	9.2	10.1	...	31.5	36.3	....	76.2	83.4	....	....	311.1	319.0	.....	.....
2 Ounce Halved	1	1.8	...	4.0	3.1	....	23.6	23.7	....	93.2	96.1	....	.....	205.3	303.1	.....
3 Ounce Halved	1½	2.3	5.1	4.8	...	20.2	27.0	....	82.1	92.0	....	88.1	205.7	235.1	.....	384.3
4 Ounce Halved	2	2.5	5.5	5.3	4.1	25.9	28.8	25.8	86.6	92.1	94.0	85.8	290.4	248.0	309.0	393.0
5 Ounce Halved	2½	2.6	...	5.6	...	....	27.7	....	....	90.4	....	85.0	.....	253.3	.....	389.3
6 Ounce Halved	3	3.1	6.7	6.3	5.0	26.7	28.5	27.1	82.2	89.7	90.5	86.0	285.2	260.3	295.7	418.1
3 Ounce Quartered	¾	1.5	...	3.4	...	....	23.4	....	....	94.6	....	....	.....	187.7	.....	.....
4 Ounce Quartered	1	1.6	...	3.6	3.2	....	23.7	23.6	....	95.0	95.1	....	.....	192.9	286.3	.....
5 Ounce Quartered	1¼	1.9	...	3.9	...	....	25.6	....	....	94.1	....	....	.....	188.4	.....	.....
6 Ounce Quartered	1½	2.0	...	4.1	...	....	26.0	....	....	93.7	....	88.8	.....	199.8	.....	378.5
8 Ounce Quartered	2	....	..	...	3.8	....	....	24.3	.....	....	93.1	89.7	.....	.....	291.8	402.2
12 Ounce Quartered	3	....	..	...	4.5	....	....	24.5	....	....	90.9	....	.....	.....	288.8	.....

to accentuate the value of the larger seed to a greater degree than is shown in the experiments where the planting was done with a machine. In each of the two years there were a few hills which were badly diseased as the result of attacks of Rhizoctonia and Fusarium. These hills, which were abnormally small, were dug separately and discarded. The yields per acre were calculated on the basis of the total area planted.

Since the amount of seed required to plant a given area varies in proportion to the size of the seed piece planted it follows that the larger the seed used the greater will be the cost per acre, which must be taken into account in determining the economy of the use of the different sizes of seed. To offset this increased seed requirement for the larger sizes the amount of seed used for each size was subtracted from the calculated yield, giving what is termed the net yield. The results are shown in the 3rd, 5th, 8th, 11th and 15th columns of Table 12. Within each of the three groups the number of stems, the number of tubers and the weight of tubers per hill increased as the size of the seed piece increased. Considering only the marketable tubers we find the same general trend in the case of the number and weight and the net yield per acre though a few exceptions are noted. The most significant point in connection with the net yields is the well defined decrease where seed pieces weighing less than two ounces were used. Above that size the differences are either very small or inconsistent. The per cent of marketable tubers, as regards both number and weight, varies inversely as the size of the seed piece, the more uniform gradation being found in the yields obtained from the whole seed.

In Table 13, which is summarized from Table 12, are shown comparisons where seed pieces of the same weight are taken from tubers of different weights. In each of the first three groups, where whole seed is compared with cut seed pieces of equal weight, the whole seed produced a greater number and weight of tubers, including both the total and marketable, and a larger net yield after deducting the weight of the seed used. A comparison of the results obtained from the halved and quartered seed, which appears in the first and last groups, indicates the superiority of the seed cut in halves over that which is cut in quarters.

EXPERIMENTS OF 1918

This experiment was conducted under practical field conditions with the planting and digging done by machinery instead of by hand as in former years. The same variety, the Rural New Yorker,

TABLE 13

Comparisons of Results Obtained from Whole, Halved and Quartered Seed Where Seed Pieces of the Same Weight were Used.

SIZE OF TUBERS	Weight of Seed Piece Planted Oz.	No. of St'ms per Hill, Greeley '16–'17	No. of Tubers per Hill		Wt. of Tubers per Hill (Oz.)		MARKETABLE TUBERS						NET YIELD MARKETABLE TUBERS PER ACRE		
							Per Cent of Weight			Bushels per Acre					
			Greeley '16–'17	Greeley 1918	Greeley '16–'17	Greeley 1918	Greeley '16–'17	Greeley 1918	Carbondale '16	Greeley '16–'17	Greeley 1918	Carbondale '16	Greeley '16–'17	Greeley 1918	Carbondale '16
1 Ounce Whole	1	1.8	4.3	3.2	25.1	23.5	93.4	95.6	....	220.1	295.7	.....	217 8	282.7	.....
2 Ounce Halved	1	1.8	4.0	3.1	23.6	23.7	93.2	96.1	....	205.2	303.1	.....	193 9	290.1	.....
4 Ounce Quartered	1	1.6	3.6	3.2	23.7	23.6	95.0	95 1	....	192.9	286.3	.....	181.6	273.3	.....
2 Ounce Whole	2	2.6	6.3	4.0	30.9	26.5	90.7	93.6	90.0	292.9	332.1	443.2	270.2	306.1	420.9
4 Ounce Halved	2	2.5	5.3	4.1	28.8	25 8	92.1	94.0	85.8	248.0	309.0	393.0	225.3	283.0	370.7
8 Ounce Quartered	2	...	...	3.8	....	24.3	....	93.1	89.7	.....	291.8	402.2	.....	265.8	379 9
3 Ounce Whole	3	3.2	7.2	4.9	31 3	27.1	88 1	90 8	86.9	275 0	316.8	453.9	241 0	277.8	420 3
6 Ounce Halved	3	3.1	6.3	5.0	28 5	27.1	89.7	90.5	86.0	260.3	295.7	418.1	226.3	256.7	384.5
12 Ounce Quartered	3	...	...	4 5	....	24.5	....	90.9	....	.....	288.8	.....	.. ..	249.8	.....
3 Ounce Halved	1½	2.3	4.8	..	27.0	....	92 0	....	88.1	235.1	.....	381.3	218.1	.....	367.5
6 Ounce Quartered	1½	2.0	4.1	...	26.0	....	93.7	....	88 8	199 8	.....	378 5	182.8	.....	361.7

was used this year as in 1916 and 1917. The seed was limited to one-, two- and three-ounce sizes which included whole seed and seed cut in halves and quarters so that three sets of comparisons were obtained with each of the three kinds and sizes of seed. It has been found by previous experience that the planter would not, without modification, successfully plant sizes larger than three ounces, in fact, three-ounce seed, especially that which was cut in halves, gave some trouble. One row, 246 feet long, of each size and kind of seed was planted and the series was duplicated. Soil and moisture conditions were ideal at the time of planting which are considered largely responsible for the nearly perfect stand that was secured. The crop was practically free from disease. The results are shown in the 6th, 9th, 12th and 16th columns of Table 12.

In each of the three groups shown in Table 12 the number and weight of tubers per hill increased directly with the increase in the size of the seed piece. The percentage of the weight of tubers which were marketable varied inversely with the size of the seed piece. In comparing the calculated yields per acre the two-ounce seed appears to have produced slightly better results than either of the other two sizes though in the two groups where cut seed

Fig. 5—Residence and laboratory at experiment station.

was used the differences are so small as to suggest that they are within the limits of error.

The comparisons of whole, halved, and quartered seed where seed pieces of the same size were used, show that the kind of seed had practically no influence on the number and weight of the tubers produced in the one-ounce group. In the two- and three-ounce groups there was a decided falling off in tuber production per hill where quartered seed was used. Within each group there was little difference in the per cent of marketable tubers. The yields of marketable tubers per acre, also the net yields after deducting the weight of the seed used, were, in all cases except one, largest where whole seed was used, with the yields from halved seed next in order. In the one-ounce group the slightly lower yield where the whole seed was used is believed to be due to so-called experimental error, which is indicated by the abnormally low yield produced by the one-ounce whole seed in the first series of this experiment. In the second series the yield from the corresponding plot was in line with those of the other groups.

COOPERATIVE EXPERIMENTS AT CARBONDALE, COLORADO

In 1916, in addition to the work which was carried on at the station with the different sizes of seed, an experiment was conducted on a field basis at Carbondale on the ranch of the Crystal River Land Company, commonly known as the Sweet Ranch. The relatively cool summers at this place resulting from the high altitude, which exceeds 6,000 feet, coupled with the deep fertile soil of a fine sandy loam type make conditions especially favorable for potato production. At the time of planting, the soil was in excellent condition and the supply of moisture abundant. This favorable environment undoubtedly reduced to a minimum the differences in value of the different kinds and sizes of seed so far as germination was concerned. Two varieties were planted, the Russet Burbank and Peachblow. Two lots of seed were used for each variety, one grown on a special seed plot, the other taken from the ordinary market stock, both of which were grown on the ranch. Each plot consisted of one row 600 feet long. The rows were 39 inches apart and the distance between hills was 15 inches. The series was not duplicated. The crop was planted May 19 to 22 and dug October 23 and 24. Some difficulty was experienced in planting the larger sizes, particularly the five-ounce Russet Burbank seed. This may explain in part the falling off in the yield of this seed. Unfortunately this point can-

not be checked up by the stand since no counts were made of the number of plants in each row. The separation into marketable and culls was made with a sorter using a 1⅞-inch screen for the Russet Burbank and a 2-inch screen for the Peachblow. The sorting was done February 7 and 8. The averages of the yields from the four sources of seed are shown in the 13th and 17th columns of Table 12 and the 10th, 13th and 16th columns of Table 13.

While the results are somewhat conflicting, considered as a whole, the general tendency is toward an increase in yield of marketable tubers corresponding with the increase in size of the seed piece planted. After deducting the amount of seed used the net yields from the smaller sizes are slightly larger in the case of the whole seed though the differences are small, while with the cut seed there is in general an increase with the larger sizes. Comparing whole and cut seed where seed pieces of the same weight were used we find a significant increase in favor of the whole seed. The two comparisons of seed cut in halves and in quarters show a smaller yield from the seed cut in halves in the case of the two-ounce seed pieces and a larger yield where the 1½-ounce seed pieces were used. The differences, however, are so small as to have little significance.

GENERAL SUMMARY OF SIZES OF SEED

Considering the results of all the size of seed experiments as a whole, we find the superiority of whole seed clearly shown. This form of seed has consistently produced a better stand, a larger total yield and generally a larger yield of marketable tubers than cut seed. Whole seed was also found to produce a greater number of tubers per hill which, however, were in most cases of smaller average size than those grown from cut seed. This feature may be utilized to advantage in controlling to a certain extent the character of the crop. For example, the Rural New Yorker normally sets a small number of tubers, some of which usually develop into oversized stock. The use of whole seed, which would tend to increase the number and decrease the size of the tubers, would undoubtedly result in a crop of greater uniformity and better quality than that grown from cut seed. On the other hand, the Charles Downing, a variety in which the percentage of small tubers is so large as to be considered an undesirable characteristic, would, it is believed, produce more profitable crops if cut seed were used, provided as good a stand were secured from this kind of seed as from whole seed.

A study of the influence of the size of seed piece on the yield

shows some inconsistencies, which may be attributed chiefly to the effect of the different conditions under which the crop was grown during the course of the experiment. There appears to be a direct relation between the size of the seed piece and the yield where the seed was subjected to unfavorable conditions during the period of germination, as was the case in 1916 and 1917. On the other hand, where conditions were favorable during this period, this relationship is not so apparent; in fact, after deducting from the marketable tubers the amount of seed used, the larger sizes of seed were found to be less economical. It is, however, essential in all cases to use a seed piece of sufficient size to furnish the necessary amount of food material to give the young plants a good start and especially to insure against loss of stand due to unfavorable conditions during germination which cannot be foreseen at the time of planting. The experimental results indicate that while the most economical size of seed to use may vary according to conditions, it should at least equal or exceed two ounces in weight.