GROWING POTATOES in COLORADO

By C. H. Metzger

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GROWING POTATOES IN COLORADO

By Carl Metzger

There has never been a period, since the potato industry in Colorado started 60 years ago, when it was more necessary for growers to examine their production methods. Now is the time to determine whether they are producing the best quality possible at the lowest possible cost. The last few years have brought a great many changes to the potato industry and it is going to take some time to become adjusted to them.

There has been a material reduction in the consumption of potatoes due to several causes: The purchasing power of the public has been very low and other fresh vegetables and fruits have replaced the potato in the diet to a considerable extent. Prices received by growers have been the lowest on record. The trucker has introduced a new method of transportation and merchandising, which has had a tendency to shift production toward the consuming centers. Colorado growers have also experienced keener competition from other states.

One of the most vital changes affecting the potato grower is the reduction in the per capita consumption. The part of the population which consumed the most potatoes was most vitally affected by the recent depression. The laboring classes had their incomes so seriously reduced that they were unable to buy normal quantities of even so staple an article of diet as potatoes. Another cause of reduced consumption is the increased competition from fresh fruits and vegetables. The tremendous increases in the acreages of head lettuce, cauliflower and pod peas, have been felt by the potato industry. A human being can consume just so much food (estimated at 2,100 pounds annually) and when he increases his consumption of one commodity it is most generally at the expense of some other commodity. The tremendous amount of publicity on vitamins and their occurrence in fresh fruits and vegetables has done much to stimulate their consumption, partly at the expense of potatoes. Potatoes have been more directly attacked recently, with the charge that they are fattening. This propaganda has also had some effect on consumption. The per capita consumption is commonly considered 3.5 bushels, which means that a 420,000,000-bushel crop is required. Such was the crop of 1924 when the December 1 price to growers was one dollar per hundred. Such a crop today would

Cover Picture—Harvesting certified Irish Cobbler seed at 9,300 feet above sea level.

probably render western potatoes practically worthless. It is very doubtful if the per capita consumption is over 3 bushels, which means that 360,000,000 bushels are required for the United States. This was the size of the 1930 crop when the December price to growers was also one dollar per hundred.

In addition to the decreasing per capita consumption, the average December 1 price to growers for the past 3 years was the lowest on record, being only 38 cents per bushel. The lowest previous 3-year period was 1895 to 1897, inclusive, when the average price was 45 cents per bushel. The price for the 1932 crop was 24 cents per bushel, the lowest on record. The United States crop in that year was normal, being 358,000,000 bushels. The previous low was in 1891, when the price was 28 cents per bushel. Even the large 1922 crop brought growers 37 cents per bushel on December 1, and the extraordinarily large 1928 crop was reported at 45 cents per bushel on December 1.

Reduced consumption and low prices are not the only problems confronting Colorado growers. The trucker has introduced a new method of transportation and marketing. It was feared by many that this new method would cause a shift of production centers to areas of large population. This would indeed be serious for the Colorado growers. While it is true that production has increased in deficient producing states, it hardly seems possible that this increase will be maintained in the face of competition from a superior quality product from western states. Truck transportation has undoubtedly been of benefit to certain isolated districts in the state which formerly had no outlet for their crop. The trucker has been seriously attacked as a detrimental influence, but space cannot be taken here to present the various sides of the case. There is one point which should be made, however, in regard to the charge that the trucker hauls and sells a poor-quality product. The trucker cannot be held altogether responsible for the quality of the product he hauls and sells because he buys this product from the farmer. The responsibility for the quality of the trucker's potatoes rests largely with the farmer. There is no question but that the trucker has a permanent place in the potato industry, as practically the entire potato demand of the city of Detroit is now supplied by trucks. Just what his place is will be determined by usage, public opinion, and perhaps legislative regulation.

Another factor to be considered by Colorado potato growers is the increasing competition from other states. Idaho has doubled its production in the last ten years. Washington, Utah and California have shown large increases. These states not only shut off Colorado's outlet to the west, but have moved increasing quantities of potatoes into eastern and southern markets. New Mexico and Arizona now afford a market for Colorado potatoes but are increasing

their production. Nebraska and Wyoming have also increased production and are shipping to the same markets as Colorado. Texas and Louisiana were markets which Colorado had practically to herself until the fall of 1931, when Maine started shipping by boat to Atlantic and Gulf ports.

In spite of all these unfavorable factors, Colorado still has an ideal climate and soil for potatoes. Just as high yields can be obtained in Colorado as can be obtained anywhere and the quality produced is better than that of most growing districts. Colorado growers can keep their costs down by obtaining high yields of quality potatoes per acre. There is no justification for expansion of acreage at this time. Each grower must plant only the best seed obtainable. He must get some organic matter into his soil. He must rotate his crops and treat his seed to keep down soil-borne diseases. He must plant more carefully to secure better stands. He should plant only the standard varieties for his district. He must use every precaution to prevent bruising in harvesting and storing. It is only by doing these things that he will be able to meet these changes in the industry. This bulletin outlines the best-known methods of production and it is only by following them that Colorado's position can be maintained.

IMPORTANCE OF POTATO PRODUCTION IN COLORADO

Colorado ranks ninth in production among the states with an average 10-year (1922-1931) annual production of 13,583,000 bushels. The potato crop is equal in value to that of all other vegetables produced in the state. Its average valuation is over $8,000,000 and is exceeded only by corn, hay, sugar beets and wheat. It is grown on 15,043 farms or 25 percent of all farms in the state, according to the 1930 census. The average acreage per farm is 5.94. Potatoes occupy only 1.5 percent of the harvested area of the state. Colorado has only 3 percent of the United States acreage and 4 percent of the United States production. Only 82 percent of the Colorado potato acreage is irrigated and the average yield is 156.37 bushels. The remaining 18 percent is dry land, where the average yield per acre is 67.09 bushels.

The average yield for the state is only 139 bushels (1919-1928) in spite of the exceptionally high yields often obtained. Colorado ranks ninth in average yield per acre, while, according to its natural advantages, it should be at least in third place. The states in which the average yield per acre exceeds that of Colorado are: Maine 246, Idaho 181, Utah 157, Nevada 148, Washington 148, California 146, New Hampshire 145 and Vermont 144. The figures are the average for 10 years, 1919-1928, from the U. S. D. A. Yearbook of Agriculture, 1931.

Table 1*. Rank of leading potato-producing states with production, acreage and yield.

	State	Production in Bushels Av. 1924-1928	Acreage 1924-1928	Yield Bushels per Acre Av. 1919-1928
1.	Maine	38,559,000	149,000	246
2.	Minnesota	34,704,000	319,000	99
3.	New York	31,046,000	274,000	113
4.	Michigan	29,403,000	268,000	104
5.	Wisconsin	27,624,000	244,000	106
6.	Pennsylvania	26,036,000	215,000	112
7.	Idaho	17,131,000	92,000	181
8.	Virginia	16,615,000	135,000	115
9.	Colorado	12,419,000	84,000	139
	United States	392,605,000	3,363,000	109

*U. S. D. A. Yearbook, 1931.

Colorado owes its position in the industry to ideal soil and climatic conditions. The yields in the commercial districts are quite high and the cost of production is very low. The quality is excellent. The tubers are for the most part bright, clean, well graded and well packed. The starch content is high so the tubers are mealy when cooked. Colorado is quite close to good markets to the south and east. About 60 percent of the crop is shipped and Colorado ranks seventh in the number of cars moved. Most of the shipments consist of varieties not grown in other states, so competition is not quite so keen. In fact, the Peachblow tops the Chicago market. The carlot shipments since 1920 are given in Table 2.

TRENDS IN ACREAGE, PRODUCTION AND YIELDS

Potato acreage in Colorado has shown a steady increase since 1880, with the exception of the 5-year period from 1915 to 1919,

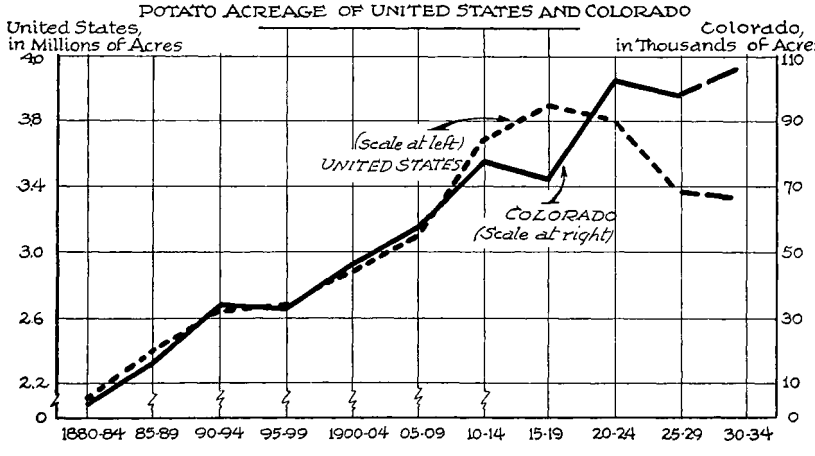

Fig. 1. Acreage trends in Colorado and the United States.

Table 2. Potato production, acreage, yield, carload shipments and price for Colorado and the United States from 1920 to 1933, inclusive.

	Colorado (1)					United States (2)				
Year	Acres, Thousands	Production in Bushels, Thousands	Yield, Bushels per Acre	Price to Growers Dec. 1 (per Bu.)	Cars Shipped	Acres, Thousands	Production in Bushels, Thousands	Yield, Bushels per Acre	Price to Growers Dec. 1 (per Bu.)	Cars Shipped
1920	73	9,490	130	$0.80	11,229	3,657	403,296	110.3	$1.145	185,176
1921	113	14,916	132	0.73	17,697	3,941	361,659	91.8	1.101	218,001
1922	142	18,460	130	0.37	15,674	4,307	453,396	105.3	0.581	245,407
1923	110	13,530	123	0.53	13,870	3,816	416,105	109.0	0.781	241,603
1924	71	10,295	145	0.60	12,386	3,310	419,560	126.8	0.625	252,097
1925	62	12,090	195	1.55	15,422	3,074	320,915	104.4	1.870	241,523
1926	82	11,890	145	1.30	14,200	3,120	354,458	113.6	1.414	232,424
1927	96	14,400	150	0.55	17,328	3,476	402,741	115.9	0.965	253,445
1928	110	13,420	122	0.45	13,714	3,837	465,350	121.3	0.539	257,343
1929	90	14,670	163	1.10	15,336	3,338	359,048	107.6	1.309	253,194
1930	92	17,480	190	0.60	18,080	3,394	361,090	106.4	0.904	251,387
1931	101	9,595	95	0.30	7,481	3,366	372,994	110.8	0.429	.....
1932(3)	100	11,000	110	0.24	7,266	3,381	358,009	105.9	0.350	185,961
1933	87	13,050	150	0.48	(4)8,613	3,184	317,143	99.6	0.700	(4)154,904

(1) Colorado Yearbook, 1932.
(2) U. S. D. A. Yearbook, 1931.
(3) Colorado Crop Reporting Service.
(4) To February 23, 1934.

inclusive. The decline in acreage during this period was a reaction from the failures perhaps due to psyllid yellows from 1911 thru 1914. The United States acreage, on the other hand, has shown a steady increase with the growth of population. The peak in acreage, however, occurred in the period between 1915 and 1919 and has been declining since that time. The trend in acreage for Colorado and the United States is shown in Figure 1.

The increase in production, like the increase in acreage, has been almost continuous since 1880, with the exception that the production during the 5-year period, 1910 to 1915, was low in Colorado. In 1911 the crop in the state amounted to only 3,000,000 bushels. The production in the United States has shown a steady increase except for the last 9 years during which there has been a downward trend. The trend in Colorado and United States production is shown in Figure 2.

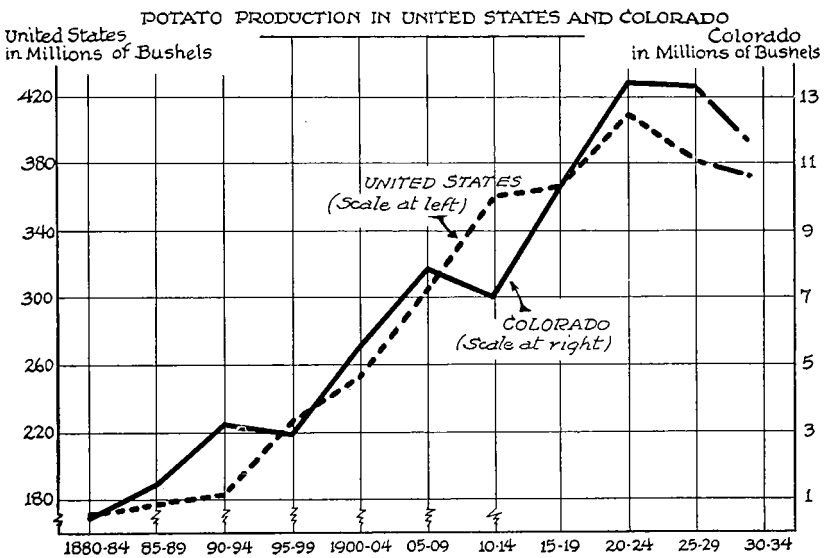

Fig. 2. Production trends in Colorado and the United States.

The average yields per acre for Colorado and the United States are shown in Figure 3. The average yield per acre in Colorado has shown a decided upward trend, except during the psyllid-yellows epidemic of 1911 to 1914. The last 4 years show a considerable drop in the average yield because of the drouth in 1931. The tendency in the United States is also for a higher yield per acre. The increase is especially marked since the introduction of certified seed in 1917.

The average farm price per bushel on December 1 is shown in Figure 4. The high prices during the first period were, of course, due to the mining industry. For the following 30 years the average

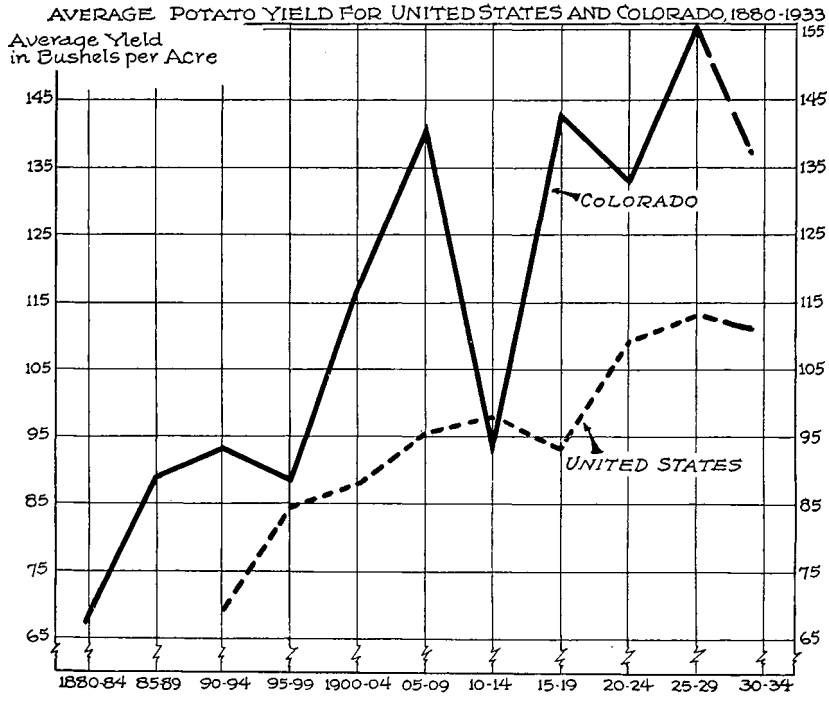

Fig. 3. Yield trends in Colorado and the United States.

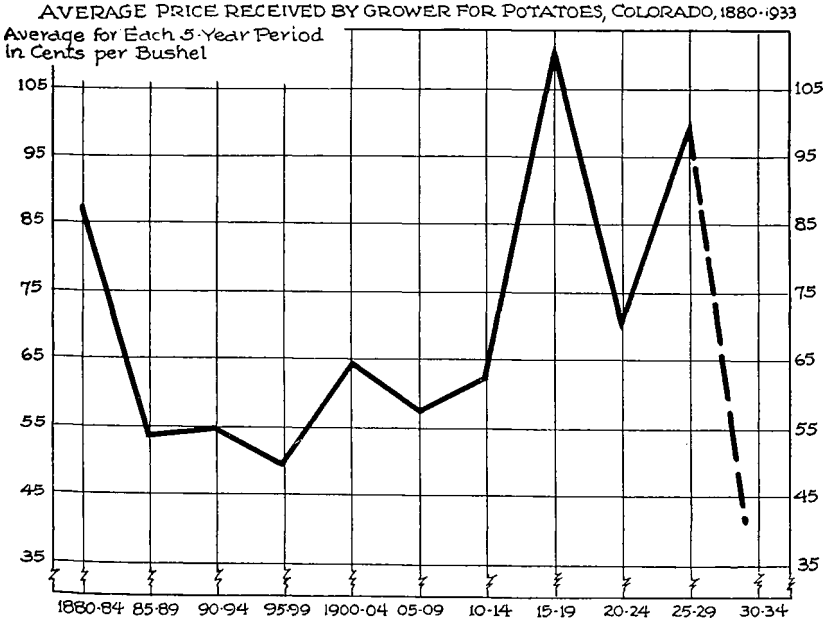

Fig. 4. Price trends in Colorado.

price to growers was 95 cents per hundred. The war period jumped this price to $1.80 per hundred. During the next period prices went down almost to their former level, averaging $1.00 per hundred, but rose again to $1.65 during the next 5-year period. The past 4 years show the lowest average price since the potato industry started in this state, being only 67 cents per hundred.

POTATO-GROWING DISTRICTS

There are four main commercial districts in the state and five other districts of lesser importance. Some sections of the state were important potato producers in early days because of a good local market. Lack of transportation facilities prevented competition with a superior product from other districts. The river bottoms were the first and only lands used for potatoes during the early settlement of the state. Today it is impossible to grow potatoes on most of these lands, much to the bewilderment of "old-timers." A part of the reason probably lies in the fact that the development of irrigation on higher lands away from the streams caused a rise in the water table

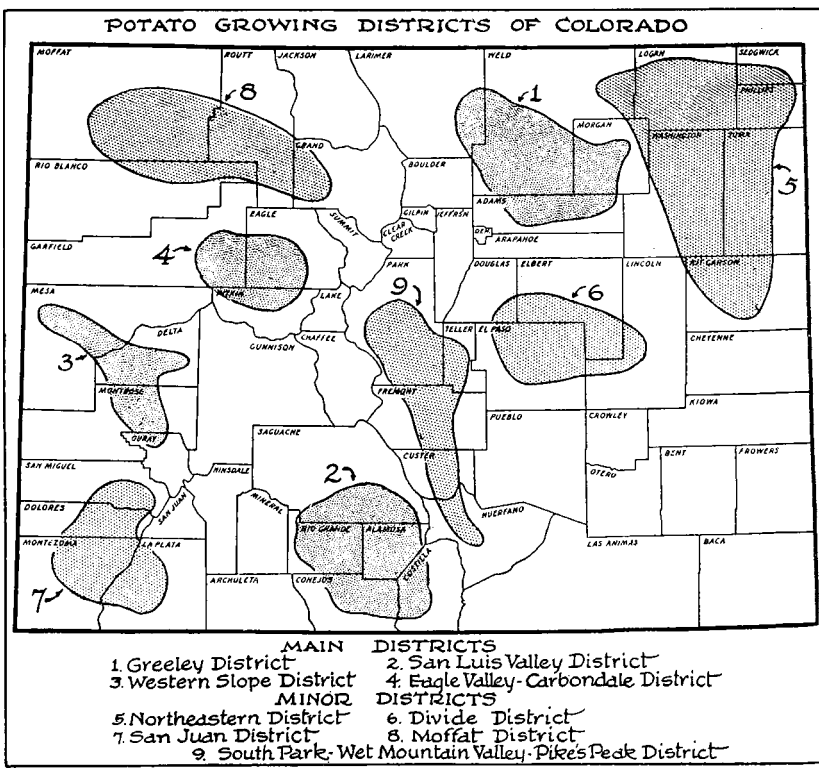

Fig. 5. Potato-growing districts.

in the river bottom. Diseases and insects, especially the epidemic of 1911-1914, have dealt a serious blow to the industry and some sections have not recovered.

On the other hand, the rise of other sections has been nothing short of phenomenal. Hundreds of thousands and even millions of acres of excellent potato land are still undeveloped and need only water to come into production. Other excellent sections need only adequate and cheap transportation to become first-rate commercial districts. Some of these lands will probably never be developed because of an inadequate water supply, but there will undoubtedly be new commercial districts developing for some time to come. The 1930 census shows the size of the industry in the state in 1929.

Table 3. Size and importance of the potato industry in Colorado.

Acreage 1929	Production in Bushels	No. of Farms Report. Potatoes	Acreage 1924	Acreage 1919
89,692	14,649,446	15,043	64,560	77,337

THE SAN LUIS VALLEY.—This district has just within the last 15 years replaced Greeley as the largest potato-producing district in the state and 25 years ago was of only minor importance. It consists of 5 counties, is 120 miles long, 60 miles wide and contains over 3,000,000 acres. Less than one-fourth of it is under cultivation. The annual precipitation is less than 10 inches and all crops are produced under irrigation. Potatoes are produced at altitudes of from 7,500 to 8,500 feet. The valley is surrounded by mountains, but the floor of the valley is nearer level than any other district of its size in the state. It is thought that the entire valley is an old lake bed. The soils are generally sandy or gravelly loams with a few heavier soils. The tubers are generally "netted" or flaked and very clean.

The highest yields in the state have been produced in this district. The highest was obtained by L. G. Schutte of Monte Vista with 1,145.17 bushels of Brown Beauties on a measured acre in 1929. This was the American record until 1933 when Zuckerman at Stockton, California, obtained 1,155.83 bushels. The chief varieties are Peachblow, Brown Beauty, Triumph, and on the more fertile soils, especially along the river, Russet Burbank. The Rio Grande River heads in the mountains on the west side of the valley. There was no large commercial district which planted poorer seed until 1933. With the seed program now well under way and with some concerted effort to increase the organic matter content of the soils, the average yield for the valley should be doubled in the next 10 years. The census figures for the 1929 season in Table 4 give some idea of the industry in this district:

Table 4. Census figures for the San Luis Valley.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Rio Grande.....	19,655	4,424,489	586	13,205	12,317
Saguache	7,353	1,603,477	287	3,707	2,233
Alamosa	5,754	1,103,727	318	1,405	1,942
Conejos	5,221	957,927	548	1,307	2,714
Costilla	291	37,429	127	14	230
Total	38,274	8,127,049	1,866	19,638	19,436

GREELEY.—This is the oldest commercial district in the state. Production started in 1870 and reached its peak in 1909. At its height the district produced between 4 and 6 million bushels and shipped between 8,000 and 14,000 cars annually. In 1911, a disaster overtook this district which hardly has a parallel in potato history. The entire state only produced around 3,000,000 bushels that year, mostly on the mountain mesas, and the Greeley crop was almost a total loss. This epidemic lasted until 1915, when a normal crop was produced on a greatly reduced acreage. The cause of this epidemic, for years, remained unknown, but the description of psyllid yellows by Richards, of Utah, in 1927, left little doubt that this was the cause of the epidemic. The same trouble has again occurred for the past 2 years on a smaller scale. This epidemic was a serious blow and the Greeley district has never regained its former prominence.

The district contains parts of four counties and is all irrigated. The altitude is between 4,500 and 5,000 feet. The Platte River and its tributary, the Poudre, supply the water for the district. There are several types of soil, from sandy around Galeton to clay loam around Greeley. The chief varieties are Rural, Russet Rural, Triumph and Cobbler.

The district has had more than its share of troubles in addition to those already mentioned. The summer temperature occasionally gets high enough to reduce yields; fusarium wilt is more prevalent than in any other part of the state; this is the native habitat of the Colorado potato beetle; and flea beetles which "worm track" the tubers are plentiful. Sprays have been developed by the Experiment Station to control these insects. Growers often plant too late for the crop to mature, with the result that the tubers are skinned and "feathered." There is somewhat of a revival of interest at present and more and more growers are producing better quality stock.

Most of the crop is now moved by truck, a large portion going to the Denver market. The old practice of importing seed from the drylands or mountains should be given more attention; spraying for insect control should be adopted as a general practice; late varieties should be planted earlier and irrigation stopped in time for the tubers to mature. Every effort is being made to obtain better varieties for this district.

The district produces both early and late potatoes. The earlies, grown around Fort Morgan and Brush in Morgan County and scattered more or less in Weld County, are marketed as early as the first week in July and continue coming on until September. The late crop is not dug until October and conflicts to a considerable extent with beet harvest. The figures from the 1930 census in Table 5 give some idea of the size of the industry and the trend in this district.

Table 5. Census figures for the Greeley District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Weld	22,767	2,657,520	1,762	16,099	15,622
Morgan	1,442	285,688	180	657	1,250
Larimer	578	45,751	234	281	543
Adams	312	30,426	106	235	1,286
Total	25,099	3,019,385	2,282	17,272	18,701

THE WESTERN SLOPE.—This district includes four counties in the Grand, Gunnison and Uncompahgre Valleys. The mesa lands and lighter soils are ideally suited to potato production, but the heavier soils are a serious problem to the industry. Remoteness from market has been a serious handicap to this district and in seasons of low prices the freight rates make shipping almost prohibitive. The district is of considerably less importance than the two previously mentioned, as the figures in Table 6, from the 1930 census, indicate.

Table 6. Census figures for the Western Slope District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Montrose	4,282	877,089	678	7,611	7,079
Mesa	1,363	170,336	695	3,022	1,619
Delta	851	136,180	547	1,641	2,916
Ouray	221	25,718	114	262	273
Total	6,717	1,209,323	2,034	12,536	11,887

Both acreage and production figures in the above table are a little low for the average of this district.

This district has the mildest climate in the state and as a result produces more early potatoes than other districts. The Fruita district in Mesa County leads in this respect, originating shipments as early as the last week in June. The production of early potatoes extends up the Gunnison Valley into Delta County and up the Uncompahgre Valley into Montrose County. Irish Cobbler is the chief variety used, altho Triumphs are now being planted to some extent. Late potatoes are planted to some extent in Delta County and comprise the major portion of the production in Montrose County. The

chief varieties are Rural, Peoples Russet, and on the lighter soils, Peachblow. Excellent certified seed is produced without irrigation on the higher mesas. Potatoes are grown at altitudes ranging from 4,500 to 9,000 feet.

Bostwick Park in Montrose County is one of the most ideal potato-growing locations in the state. The average yields are very high, exceeding 400 bushels, the quality is excellent and an ideal rotation is followed. A large number of the growers are members of the 600-Bushel Club.

THE EAGLE VALLEY-CARBONDALE DISTRICT.—This district is also on the western slope of the mountains. Commercial production dates back to about 1900, but potatoes have been grown here for local mining trade since the early settlement of the state. The smallest acreage of any of the four commercial districts is found here but the highest average yields per county are obtained.

Table 7. Census figures for the Eagle Valley-Carbondale District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Garfield	2,616	548,508	489	3,411	2,856
Eagle	1,133	293,769	182	1,862	1,584
Pitkin	960	196,872	121	1,217	921
Total	4,709	1,039,149	792	6,490	5,361

The district is composed of the Eagle River Valley with the valleys of its tributaries, Brush Creek and Gypsum Creek; and Crystal River, Roaring Fork and Frying Pan Valleys and adjoining mesas, with Carbondale as a center; along the Colorado River Valley

Fig. 6. Inspecting potato plots on Farmers' Day at the Mountain substation.

and adjoining mesas with New Castle and Rifle as centers. The altitude varies from 5,000 to 8,500 feet. The Russet Burbank is by far the most popular variety. The famous "Red Soil Russets" are grown on a few farms up Gypsum Creek and around Glenwood Springs, which are the only places these peculiar soils are found. The Peoples Russet is grown on the heavier soil and in the warmer climate around Rifle. The Russet Rural, introduced by the Agricultural College to replace the Peoples, is gaining in popularity. Rural New Yorkers are also grown to some extent and the Triumph is gaining in popularity because it can be dug earlier than the other varieties.

This is such an ideal potato district that seed stocks have been used for years without change or without any attempt at improvement except bin selection. The result has been that seed stocks have degenerated so gradually that it has escaped the growers' notice. A few of the most successful growers make a practice of planting certified seed produced in the adjoining high altitudes every year. Seed should be changed oftener than has been the general practice in the past. In spite of more or less systematic rotations, some of the soils are lower in organic matter than they should be, with the result that some of the potatoes are severely criticized because they have too much dirt stuck to them.

THE WET MOUNTAIN VALLEY, SOUTH PARK AND PIKES PEAK DISTRICT.—This district is of only minor importance commercially. Most of the table stock is disposed of locally, but a considerable quantity of certified seed is produced and the district is becoming more important. Variety standardization did not begin until about 5 years ago and is not yet entirely completed. The chief variety is the Peachblow, with a few Triumphs, Cobblers and Brown Beauties grown mostly for seed.

Most of the potatoes are grown without irrigation at altitudes ranging from 7,000 to 10,000 feet. Psyllid yellows has caused some damage during the past 2 years and may have a serious effect on the future development of this district.

Table 8. Census figures for the Wet Mountain Valley, South Park and Pikes Peak District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Custer	1,482	166,556	239	336	1,182
Park	1,351	103,213	203	430	969
Teller	1,315	110,764	191	402	1,100
Fremont	318	24,617	84	254	529
Huerfano	167	13,070	57	95	163
Total	4,633	418,220	774	1,517	3,943

THE NORTHEASTERN DISTRICT.—Except for about 600 acres, this district is non-irrigated. In Logan and Sedgwick Counties there is a

continuation of the Greeley, Fort Morgan and Brush conditions in the Platte Valley. The general conditions in the district extend into northeastern Weld County and into Western Nebraska. This district has been up and down in the potato business since an early date and the acreage has fluctuated largely with prices of potatoes or with the abandonment or introduction of other crops. It now appears that the acreage will increase for the next few years. This district produces certified seed, most of which is used in the Greeley district. The altitude is a little under 5,000 feet.

Table 9. Census figures for the Northeastern District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Logan	954	66,158	524	540	241
Yuma	577	36,637	678	445	430
Kit Carson	502	18,106	364	258	746
Sedgwick	400	43,587	87	311	777
Washington	397	26,283	445	208	485
Phillips	203	12,541	318	146	138
Total	3,033	203,312	2,416	1,908	2,817

THE SAN JUAN BASIN.—This district is developing rapidly both as a seed and as a table-stock district. Its isolated position on a narrow-gauge railroad made shipments possible only in seasons of very high prices. Most every variety ever grown in the state could be found here in small patches and even these small patches did not consist of one variety, but a mixture of all. In those occasional seasons when carloads were shipped the grade was "unclassified" because it was almost impossible to find a carload of one color or one type. This condition is rapidly changing, however, since the development of trucking has given this region an outlet to the south. The development of the certified seed business in the last few years has led to the standardization of varieties. This district is admirably adapted to potatoes and the highest-quality seed is produced at the higher elevations. The altitude for potatoes varies between 6,200 and nearly 10,000 feet. The main variety at present is the Irish Cobbler, with Rural New Yorker, Bliss Triumph and Peachblow grown to some extent.

Table 10. Census figures for the San Juan Basin District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
La Plata	840	92,163	578	575	881
Montezuma	777	77,094	449	467	409
San Miguel	154	18,269	114	76	181
Dolores	169	12,747	82	91	86
Total	1,940	200,273	1,223	1,209	1,557

THE MOFFAT DISTRICT.—This is another section in which there are tremendous undeveloped possibilities in potato production. This district is also isolated and lower freight rates, which now seem assured by the Dotsero Cutoff, should bring an increase in shipments from this area. The soils, both irrigated and dryland, are well suited to the crop. Good yields are obtained and the tubers come out bright and clean. The altitudes range from 6,000 to 8,500 feet. The Triumph is by far the best-adapted variety. Cobblers and Peachblows are also grown. Excellent seed potatoes are produced in this district.

Table 11. Census figures for the Moffat District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
Routt	958	120,658	478	423	589
Moffat	544	48,964	421	461	785
Grand	80	7,862	67	53	86
Rio Blanco	96	12,044	168	139	176
Total	1,678	189,528	1,134	1,076	1,636

THE DIVIDE DISTRICT.—This district was one of the first in the state to develop commercially. It supplied the Denver market with table stock and the Greeley district with seed stock. The crop failed previous to 1909 as did likewise an attempt by the Experiment Station to grow potatoes at Elizabeth in that year. This failure could not be explained at the time but in the light of our present knowledge it is quite certain that these failures were due to psyllid yellows. The author has personally found the insect and the disease in various parts of this district every season since 1928. The failures seem to occur in irregular cycles. The altitude is between 6,000 and 7,500 feet. The chief varieties are Triumph, Early Ohio and Peachblow. High-quality certified seed is still produced in certain parts of this district. The entire district is non-irrigated.

Table 12. Census figures for the Divide District.

County	Acreage 1929	Production, Bushels	No. of Farms Reporting Potatoes	Acreage 1924	Acreage 1919
El Paso	524	32,429	268	524	2,792
Elbert	509	26,972	466	408	2,454
Lincoln	306	16,152	311	576	1,397
Douglas	196	11,526	115	83	277
Total	1,535	87,079	1,160	1,591	6,920

Other districts of the state grow very few potatoes altho some of them grew a few in the early days and others have never been successful. The latter is true of the entire Arkansas Valley from Canon City to the state line. Other districts failed early; some produced only an occasional crop. These districts include Rye, the

Fountain Valley below Colorado Springs, Golden, Denver, Longmont, Stove Prairie, Virginia Dale and Fort Collins. It is interesting to note that all of these places lie along the foothills of the eastern slope except the lower Arkansas Valley. Failures were also reported previous to 1909 at Brush and Julesburg. Fitch reports in 1910 that "the plants, in such of these cases as have been observed, appeared to have the leaf-roll disease." It has now been quite definitely proved that the leaf-roll disease reported by Fitch* was psyllid yellows. The most serious limiting factor in the success of most of these districts was, and probably still is, psyllid yellows, altho the soils in most of these sections are not well adapted to potatoes, and in some cases, as previously mentioned, the drainage is poor.

CLIMATE AND SOIL

Cool weather during the growing season is necessary for the successful production of potatoes. This fact confines main-crop production to the northern states and to high altitudes. Early crops are produced in warmer sections by planting early and harvesting before hot weather arrives. Altho all other surplus-producing potato states lie north of Colorado, mean temperatures are very similar because of the high altitude of Colorado. Potatoes are grown in this state at altitudes ranging from 4,000 to 10,000 feet above sea level. The normal mean temperatures of the main growing sections in Colorado compared with those of Aroostook County, Maine, the largest potato-producing county in the United States, are shown in Table 13.

Table 13. Mean temperatures by months during growing period (°F.)†.

Place	County	April	May	June	July	Aug.	Sept.
Garnett	Alamosa	...	49.2	58.6	62.6	61.2	54.5
Greeley	Weld	...	56.8	66.6	70.9	70.0	61.2
Montrose	Montrose	...	57.6	65.2	70.6	68.4	61.0
Glenwood Springs	Garfield	...	52.6	60.6	65.5	65.0	57.9
Presque Isle, Me.	Aroostook	...	50.6	58.5	65.9	63.7	54.1
Early Districts:							
Fruita	Mesa	50.0	58.4	68.1	74.2	...	...
Delta	Delta	50.5	59.0	68.0	74.0	...	...
Fort Morgan	Morgan	46.7	56.4	66.6	73.1	...	...

†Colorado Yearbook, 1932.

As previously mentioned, very few potatoes are grown in the southeastern part of the state, including the entire Arkansas Valley below Canon City. This section is characterized by high temperatures, low rainfall, and generally heavy soils.

The unusual amount of sunshine makes Colorado growing conditions different from those of most other potato states. It is cloudy

*Fitch, C. L. 1915. Studies of Health in Potatoes. Colo. Agr. Exp. Sta. Bul. 216.

only an average of 61 days per year; partly cloudy 153 days, and clear 151 days. This high amount of sunshine would tend to make the days unusually warm if it were not for the rarefied, dry atmosphere. The nights are always cool.

Rainfall is of vital importance on only 18 percent of Colorado's potato acreage. The mean annual precipitation in these sections varies from 14 inches to as high as 26 inches in some of the mountain sections. With proper handling, yields from 100 bushels to 400 bushels per acre are obtained in these sections.

The subsoil is of more importance than the surface soil. *The important fact is that the subsoil must be porous so that the soil will be well drained.* Potatoes are successfully grown on all types of soil from almost pure sands and gravels to heavy brown, gray, or black clay loams, some of which are practically adobe in nature. The sandy loams, however, produce the largest crops and the best-appearing potatoes; they are more easily handled in preparation, cultivation, irrigation and harvesting. The heavier soils are more expensive to prepare, apt to puddle on irrigation, produce misshapen and poorly finished tubers, harbor more insects and diseases, and make harvesting difficult as well as cause more bruising of the tubers. If present trends continue, these soils will have to be abandoned for potatoes. The mountain mesas, mountain parks and bench lands above streams usually provide ideal conditions for potatoes. The river bottoms proper are usually poor because of insufficient drainage and often adobe soils.

Altho the type of the soil may be ideally suited to potatoes, there are few soils sufficiently supplied with organic matter to produce maximum crops. Colorado is an arid state and, with the exception of a few mountain districts, the native vegetation was, and still is, very scant. As a result even the new soil has very little organic matter. Maximum yields of potatoes cannot be produced until organic matter is supplied in some form by the grower.

Even tho a grower may not have the ideal sandy loam soil, he can benefit his soil materially by adding sufficient organic matter. The water-holding capacity of the sandy and gravelly loams will be greatly increased by organic matter, and the silt and clay loams will be rendered looser and more friable. They will also not crust, bake or crack as badly, will take water more readily and handle more easily.

With the exception of a few high-altitude soils, Colorado potato soils are alkaline in reaction. The pH runs from 7 to more than 8. Alkali is not a factor in production with the possible exception of a few places. Green manuring will not only add organic matter, but will correct a slight tendency toward too much alkali if the drainage is good.

Even after 50 years of potato production, much land is still planted which is not suited to the crop. New sections are constantly developing and old sections are shrinking or expanding, depending on prices the *previous* season. The average yield per acre in Colorado is below Idaho and Maine, largely because of this condition and not because of the 18 percent of non-irrigated acreage. After a favorable season for prices, potatoes are planted on heavy lands, poorly suited to the crop, on lands on the edges of the irrigated districts where the water supply is uncertain and the soil low in fertility, or in non-irrigated sections where the rainfall is uncertain. The new growers have had little experience with the crop and the seed used is generally of the poorest quality obtainable. This condition always results in large abandonment of acreage for the succeeding 2 or 3 years with material damage to the average yield per acre for the state.

ROTATION OF CROPS

The tendency for farmers to specialize in potato production and exclude other crops and livestock from their farms has never been carried as far in Colorado as it has in the eastern states. But the specialization tendency has been carried too far in some sections, at the expense of the soil, yield and quality in the potato crop. In no case should more than one-fifth of the farmers' acreage be devoted to potatoes and much better results will be obtained if this is reduced to one-eighth. The past few years have demonstrated the impossibility of depending on potatoes alone as a source of income in Colorado. December 1 prices to growers have fluctuated from 30 cents per 100 to $4.00. Every potato farm should have enough livestock to consume the feed crops necessary in the rotation. This livestock will supply the manure necessary for maximum crops of potatoes.

As previously mentioned, the majority of Colorado soils are sadly lacking in organic matter or humus. This lack can only be made up by use of a proper rotation in which alfalfa or sweet clover is plowed under and manure is added. The large majority of high yields are obtained following alfalfa. The Greeley district has maintained profitable yields over a period of 60 years with alfalfa as the basis of a good rotation and the use of barnyard manure. The Montrose and Carbondale districts have similarly maintained yields, and the Montrose district has more members of the "Colorado 600-Bushel Club" than has any other district. From actual tests by the college, fully 85 percent of the soils in the San Luis Valley are extremely low in organic matter. Much more vegetable material must be plowed under and large quantities of manure applied over a period of years to correct this condition. If certified seed is planted and enough organic matter added to the soil, the average yield for the entire San Luis Valley could be doubled.

Fig. 7. Humus, humus, and more humus. Plowing under sweet clover 12 inches deep by L. G. Schutte, the potato king of Colorado.

A definite rotation should be adopted on every farm. A rotation reduces the tendency to fluctuate greatly the acreage planted to any one crop. It tends to stabilize the income as all the crops and livestock are *seldom* unprofitable in any one year. Soil fertility will not only be maintained but in many cases increased. Scab, rhizoctonia, fusarium and blackleg are soil-borne diseases and can be kept at a minimum only if potatoes are not grown on the same ground oftener than once in 5 years. Certain insects such as flea-beetle, wire worm, white grub and seed-corn maggot attacking potatoes are checked by a proper rotation of crops.

The value of rotation, manure and alfalfa in potato production under western irrigated conditions is clearly shown by results obtained at two United States Department of Agriculture field stations at Scotts Bluff, Nebraska, and Huntley, Montana.

A comparison of rotations 1, 2, 3 and 6 in Table 14 shows that merely alternating potatoes with another crop increases yields between 36 and 40 bushels per acre, but the soil suffers as the average yields for the last 5 years are lower than the average for the 14 years of the experiment. No. 9 shows that including another crop increases yield between 26 and 30 bushels, but also fails to maintain the fertility of the soil.

The value of manure is clearly shown by a comparison of 3 and 4 where the increase is 95 bushels; 6 and 7 increase 103 bushels; 9 and 10 increase 84 bushels; and 11 and 12 increase 19 bushels. Including alfalfa in a rotation necessarily lengthens the rotation so

Table 14. Average yields of potatoes in bushels per acre in different length rotations, and effect of manure and alfalfa at the Scotts Bluff, Nebraska, Field Station, United States Department of Agriculture.*

Rotation	Length of Rotation in Years	1912 to 1925 Bushels per Acre	1921 to 1925 Bushels per Acre
1. Potatoes continuous	1	100	101
2. Corn, potatoes	2	146	138
3. Sugar beets, potatoes	2	150	137
4. Sugar beets, potatoes (manured)	2	210	232
5. Sugar beets, alfalfa (2 yrs.), potatoes	4	276	302
6. Oats, potatoes	2	160	141
7. Oats, potatoes (manured)	2	236	244
8. Oats, alfalfa (2 yrs.), potatoes	4	275	265
9. Oats, sugar beets, potatoes	3	184	167
10. Oats, sugar beets (manured), potatoes	3	233	251
11. Oats, sugar beets, alfalfa (3 yrs.), potatoes	6	284	299
12. Oats, sugar beets (manured), alfalfa (3 yrs.), potatoes	6	305	318

*Scofield, Carl S., and Holden, James A., 1927. Irrigated Crop Rotations in Western Nebraska. U. S. D. A. Tech. Bul. No. 2.

that two effects are secured, a long rotation and the beneficial effects of alfalfa. A comparison of 3 and 5 shows that these two factors increase yields 165 bushels and a comparison of 6 and 8 shows an increase of 124 bushels because of a 2-year longer rotation and alfalfa. In all of these shorter rotations, both manured and unmanured, the potatoes were badly affected with scab even tho the seed was treated before planting. Lengthening the rotation 3 years and including alfalfa increased yields 132 bushels in the case of 9 and 11, and 67 bushels in the case of 10 and 12. It will be noted that the average yields are low and still declining in short rotations without alfalfa or manure. Alfalfa and manure give large increases in yields and the largest yields result from the use of both in the rotation. A second important fact is that yields are not declining in the alfalfa or manured rotations, but in most cases are actually increasing.

SUGGESTED ROTATIONS

SAN LUIS VALLEY.—One field should be in alfalfa and remain until the stand gets poor when it can be brought into the rotation with potatoes and a new field seeded to alfalfa. The rest of the farm can be rotated as follows: Sweet clover for pasture and green manure or hay and green manure (plus barnyard manure), potatoes; sugar beets, vegetables or small grain; (or manure here); peas seeded to sweet clover.

GREELEY.—Alfalfa, alfalfa, alfalfa (spring manure and plow last cutting under), potatoes, sugar beets (or manure here), small grain seeded to alfalfa. Corn may also be included.

MONTROSE.—Alfalfa, alfalfa, alfalfa (spring manure and plow last cutting under), potatoes, onions, corn, sugar beets or wheat, small grain seeded to alfalfa.

Table 15. Average yields of potatoes in bushels per acre in different length rotations, and effect of manure and alfalfa at the Huntley, Montana, Field Station, United States Department of Agriculture*.

Rotation	Length of Rotation in Years	6-Year Average 1912-1917 Bushels per Acre	6-Year Average 1918-1923 Bushels per Acre	6-Year Average 1924-1929 Bushels per Acre
1. Potatoes continuous	1	173.6	159.4	111.2
2. Corn, potatoes	2	233.1	184.0	130.8
3. Sugar beets, potatoes	2	245.2	222.8	151.9
4. Sugar beets, potatoes (manure)	2	271.6	203.6	256.9
5. Sugar beets, alfalfa (2 yrs.), potatoes	4	239.6	273.1	277.1
6. Oats, potatoes	2	248.2	190.7	140.6
7. Oats (manure), potatoes	2	327.8	325.5	285.2
8. Oats, alfalfa (2 yrs.), potatoes	4	180.5	208.2	217.2
9. Sugar beets, oats, potatoes	3	....	266.5	215.0
10. Sugar beets, oats (manured), potatoes	3	....	297.8	326.5
11. Sugar beets, oats, alfalfa (3 yrs.), potatoes	6	....	291.6	316.1
12. Oats (manure), sugar beets, alfalfa (3 yrs.), potatoes	6	308.8	310.1	309.6

*"The results indicate that, based upon 6-year averages, yields have shown a consistent decline in the continuously cropped plot and in the 2-year and 3-year simple rotations, while in the rotations that include manure or alfalfa, or both, yields have either been maintained near the original levels or have shown some increase in the later years of the experiment.

"The beneficial effect on the yields of potatoes when alfalfa is included in the rotation is indicated in a comparison of alfalfa rotations with rotations that do not include alfalfa but are otherwise identical. The average yield of potatoes in four alfalfa rotations during the last 6-year period was 271.4 bushels per acre, while the average yield from four comparable rotations that did not contain alfalfa was 152.9 bushels, an increase in favor of the alfalfa rotations of nearly 78 percent.

"The effect of manure in the rotation on the yields of potatoes is indicated in a study of five pairs of comparable rotations. In each pair the crops are identical, the only difference being that manure is applied in one and not in the other. The manured rotations during the last 6-year period gave an average yield of 269.7 bushels per acre, while the unmanured rotations gave an average yield of only 187.6 bushels per acre. The increase in favor of the manured rotations amounted to 82.1 bushels, or 43.8 percent."

*Hansen, Daniel; Seamans, A. E.; Kopland, D. V. 1933 Agricultural Investigations at the Huntley (Mont.) Field Station, 1927-1930. U. S. D. A. Tech. 353.

MOUNTAIN SUBSTATION.—(Former rotation)—Alfalfa, alfalfa, alfalfa, alfalfa (spring manure, plow last cutting under), potatoes, pod peas, vegetables, small grain seeded to alfalfa.

MOUNTAIN SUBSTATION.—(Present rotation)—Alfalfa, alfalfa, alfalfa (spring manure), pod peas, oats seeded to sweet clover, sweet clover one cutting hay, second cutting plowed under, potatoes, barley and peas seeded to alfalfa.

These rotations will by no means satisfy all of the potato growers in Colorado, but they may be readily adjusted to fit the crops grown. The important things are that potatoes follow alfalfa, sweet clover or even peas; that the rotation be sufficiently long; that something green be plowed under, and that manure be applied.

FERTILIZERS

The Experiment Station has conducted tests with commercial fertilizers since 1900 and numerous growers have tried them. In all this time, there have been only two or three instances where the application of commercial fertilizers to potatoes has *apparently proved profitable.* The application of potash in Huerfano County around Walsenburg has made potato production possible in a limited way. Two other tests in the San Luis Valley must be repeated at least 2 more years before any conclusions can be drawn as to the real value of these fertilizers.

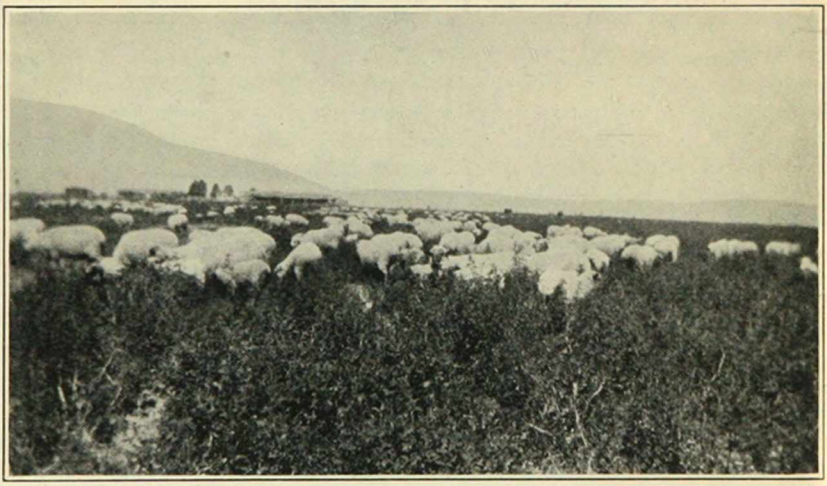

Fig. 8. Sweet clover pastured by the farm flock of sheep is excellent preparation for big yields of potatoes.

The greatest need of Colorado soils is not more plant food elements, but organic matter which increases the water-holding capacity of the soil and makes it friable or loose. Sufficient plant food will be released from the soil by the decaying of alfalfa, sweet clover or peas which have been plowed under green, or from barnyard manure which has been applied.

Manure should not be applied to the potato crop unless it is very well rotted, but should be put on some other crop in the rotation. Scab is apt to result from the direct application of manure. Ten to twenty tons per acre will pay large dividends in increased yields.

The potato farm that produces too much manure for its owner's use is yet to be discovered. The highest yields of potatoes can only be obtained when alfalfa is the basis of the rotation, and liberal quantities of manure are applied somewhere in the rotation. Sweet clover, while an excellent green manure and soil-improving crop, still needs further testing to prove that it will *replace* alfalfa in a rotation. This crop is now being tested at the Mountain Experiment Station and more definite information will soon be available.

At the present time, no form of commercial fertilizer can be recommended for Colorado potato growers. In case a grower is interested in these fertilizers, it is recommended that he *first* send a soil sample to the college for test. If the test indicates a need for some fertilizer, he should try this fertilizer on alfalfa or sugar beets. If a marked response is obtained on alfalfa or sugar beets, he should try it out on a small patch of potatoes, consulting his county agent on how it should be applied and how checks should be provided for comparison. Until the present time, more decreases than increases in yield have resulted from the use of commercial fertilizers on potatoes. If the above recommendations on rotation and manuring are carried out, the necessity for commercial fertilizers should be postponed indefinitely.

In spite of the fact that, so far, the highest yields of potatoes have been obtained on alfalfa ground, there are disadvantages to this ground. The alfalfa does not rot as quickly as sweet clover and it does not seem to flocculate the soil like sweet clover, thus causing more soil to stick to the tubers on alfalfa ground. There is also an opinion among growers, especially in the San Luis Valley, that potatoes from alfalfa ground rot in storage. This rot is more probably a result of planting seed infected with blackleg and fusarium than of the kind of ground on which the crop was raised.

SOIL PREPARATION

Potatoes, above all other crops, need a deep, mellow seedbed for their best development. The soil should be plowed as deeply as possible. With power equipment, growers in the San Luis Valley plow as deep as 14 inches altho the average in most sections is 8 to 10 inches. The chisel makes it possible to loosen the soil to a depth of 16 or 18 inches.

Fall plowing is recommended except in cases where the soil is light and is apt to blow or pack badly during the winter. Except in regions of light snowfall where clods are not broken up by freezing and thawing during the winter, the land should be left rough to catch and hold as much snow as possible. The ground should be worked down as early in the spring as possible so as to retain this moisture, as no amount of future irrigation or rain can take its place. There should be enough moisture in the soil at planting time to bring

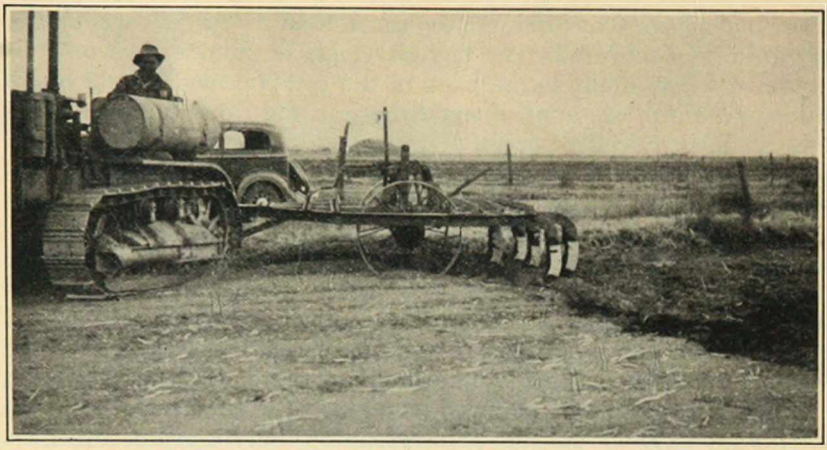

Fig. 9. A six-point chisel breaking ground 18 to 24 inches deep.

up the crop. Irrigating potatoes up is very risky as poor stands are often the result. The ground should be irrigated before planting if there is not enough moisture to bring up the crop.

The preparation of alfalfa ground for potatoes is the most difficult as more power is required to plow it and it must be properly and thoroly done to kill the alfalfa. Several systems are used depending on the type of soil and the locality. The surest method of killing alfalfa is to "crown" it (plow shallow so as to just cut off the crowns) early in the fall or late in the summer. The ground is then replowed to the proper depth late in the fall or the next spring. Little trouble with volunteer alfalfa has been experienced at the Mountain Substation where crowning has been abandoned and the last cutting of alfalfa plowed under deeply about the middle of August while the alfalfa is still growing. This latter practice has also cut the cost of production. In plowing alfalfa, sweet clover or peas under, it may be necessary to drag a chain from the plow beam to crush the plants down so they will be covered.

The general practice is to double disc the ground early in the spring or immediately after plowing if spring plowed. The disc-harrow is not the most desirable implement for this purpose as it has a tendency to pack the ground. The most satisfactory implement yet found is an old alfalfa renovator with half the teeth removed. This implement loosens the soil from the bottom and leaves it in excellent shape. The small orchard chisel also serves the same purpose.

The finishing touches are put on the field with the spike tooth harrow and the drag or leveler. This latter implement removes all ridges and depressions and leaves the field absolutely level and in

excellent shape for irrigation. It is important to remember that no amount of future cultivation can make up for a poorly or carelessly prepared seedbed.

VARIETIES FOR COLORADO

Colorado has at present nine standard varieties of potatoes. At first glance this seems like a large number but when the wide variations in soil types, altitude and climate are considered this number is not surprising. No one district grows more than four of these varieties. Practically all sections of the state have now had a taste of commercial production which has forced them to abandon old local market varieties and adopt one or more of the standard sorts.

Radical changes have taken place in the varieties grown during the past 25 years. The Pearl, 25 years ago, was the standard variety for the entire state. Its roughness and susceptibility to disease have caused it to lose popularity until today it is extremely difficult to find. Blue Victor, Beauty of Hebron, King, White Elephant, Monroe County Prize, Charles Downing, Snowflake and Rose Seedling, all once important varieties in certain localities, have now practically vanished. No one will find it profitable to grow a variety not standard for his district except in those rare cases where the grower has some special market. Trials by the Experiment Station, and the experience of growers have determined the best varieties for the different districts.

There is now more potato-breeding work going on in the United States than ever before. Several new varieties have already been introduced and more are sure to follow. These varieties are being tested by the Experiment Station as they are introduced and in cases where a definite superiority to standard varieties is shown they are being released to growers for further trial.

PERFECT PEACHBLOW (RED MCCLURE).—This variety is probably the most popular in the state at the present time. It is estimated that there are 20,000 acres planted. Its successful production is largely confined to altitudes above 6,000 feet, both irrigated and dryland, and to the lighter types of soil which are still free of scab. It has recently risen to No. 1 variety in the San Luis Valley where it reaches perfection. The skin, in this section, is quite heavily netted or flaked. The eyes are comparatively shallow and the tubers come out of the ground bright, clean and well matured. The Peachblow, or Red McClure as it is known to the trade, has topped the Chicago market for the past few years. It is higher in starch than other varieties. There are three distinct strains of this variety. One is white with red eyes and is generally sold as Brown Beauty. A second is pink with red eyes, which is the one now most generally grown. The third, which was generally introduced thru the efforts of the college in 1932, is dark red in color and will undoubtedly replace other

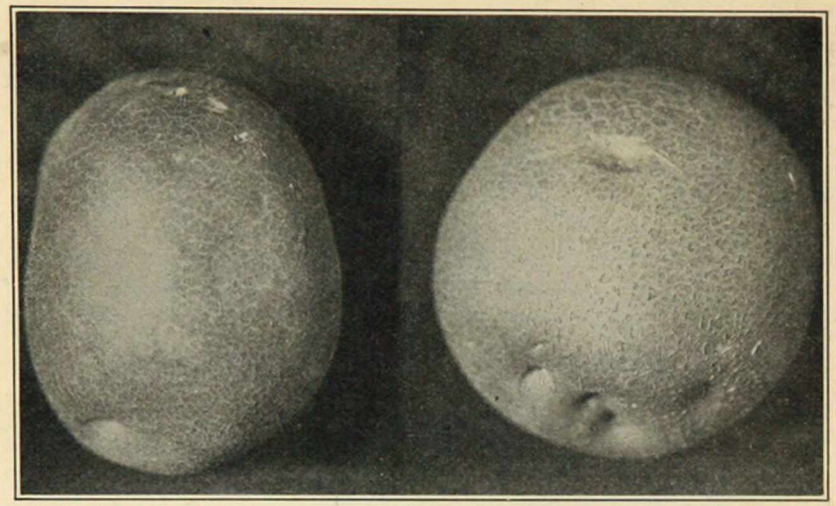

Fig. 10. The Peachblow or Red McClure is the most popular variety.

strains. It is an excellent "keeper" and can be kept in storage longer without sprouting than any other variety so far tested.

The Peachblow is a round, red variety and is late in maturing. The vine is *strong* and *upright*. The blossoms are plentiful and pink in color. It will not succeed in heavy soils or hot climates. It is very susceptible to scab and for this reason has been replaced by Russet Burbank in the Eagle Valley-Carbondale district, where it was formerly exclusively grown. It is also very severely damaged by blackleg, is moderately susceptible to mosaic and is subject to two undescribed troubles tentatively called "heart leaf" (witches broom) and "pinto giant hill" in addition to the giant hill already described by Gilbert. A tendency to growth crack under certain conditions is another fault of this variety. Seed which is free of blackleg, closer spacing, and care in maintaining an even supply of moisture will correct this condition. Hollow-heart is also sometimes observed especially on dryland. Changes in seed should be made in most parts of the San Luis Valley at least once in 5 years.

RURAL NEW YORKER.—This is Colorado's second popular variety. It is adapted to a wider range of growing conditions than the Peachblow. It succeeds on heavier soils and in warmer districts than the Peachblow and can be profitably grown in any section of the state where potatoes succeed at all, but will not produce profitable yields unless the rainfall is around 20 inches and the season is long.

The Rural New Yorker is the leading variety of the United States. It is estimated that 16,000 acres are grown in Colorado. It is the leading variety in the Greeley district and in Montrose Coun-

ty. It is also grown to some extent in the Carbondale district. The acreage of this variety is decreasing because of the introduction of more suitable varieties. It does not set as heavily as the Peachblow or Brown Beauty so can never produce the phenomenal yields of these varieties, but is well represented in the 600-Bushel Club with yields as high as 800 bushels. It must be planted as close as 9 inches in the row on fertile soils or it will become extremely large, rough and hollow. The variety seems more resistant to scab than the Peachblow.

This variety is late in maturing. The vines are medium large and somewhat spreading in habit. The blossoms are purple with white tips. The tubers are short, oval and flattened. They are white in color and the sprout tips are purple.

This variety is not well suited to the Greeley district because it is too late in maturing. Growers plant late to escape the ravages of diseases and insects and irrigate almost up to harvest with the result that the tubers are immature, low in starch, badly skinned and keep poorly. It is quite resistant to mosaic and other viruses and suffers chiefly from fusarium.

RUSSET RURAL.—This variety is identical in practically all respects with the Rural New Yorker except that there is a brown pigment in the skin and the skin is netted or russeted instead of white and smooth. It was first grown in the state a few years ago by Mr. E. R. Bliss of Greeley. It is estimated that there are now nearly 6,000 acres grown and its popularity is increasing yearly at the expense of the Rural and Peoples Russet. Because of its tougher skin it does not skin or bruise as readily as the Rural.

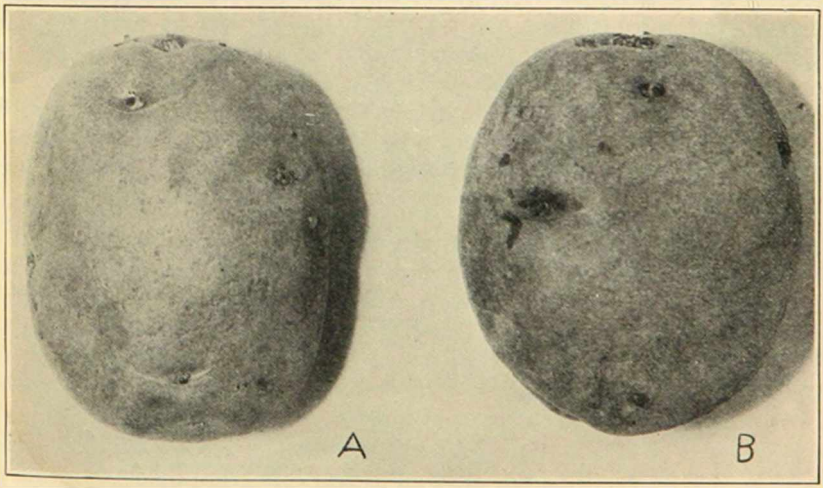

Fig. 11. The Rural New Yorker is the hardiest of the late varieties.

Recent analyses by the chemistry division of the station indicate that the Russet Rural contains more starch than the Rural. When grown on light-colored soils of the lighter types, it is a beautiful potato of a golden russet color. When grown on the heavier or dark-colored soils it is somewhat unattractive in appearance.

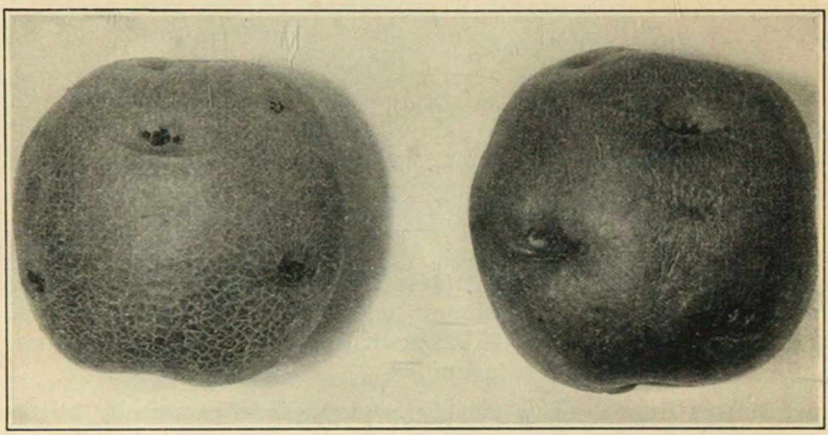

Fig. 12. The Triumph is the most popular early variety and can be grown in all districts.

BLISS TRIUMPH.—This is the leading early variety of the state and is consistently gaining in popularity. It succeeds in all potato districts of the state and is the standard variety for the dryland sections where it has largely replaced the Early Ohio. It is gaining popularity in the early districts where the Irish Cobbler was exclusively grown, but most strains are not ready to harvest as early as the Cobbler. It is also grown for early digging in all the late or main-crop districts. In the Greeley district it is also planted late and grown as a late or main-crop variety. It matures, does not skin, and does not have some of the more serious faults of the Rural. It is estimated that 15,000 acres of Triumphs are planted in the state.

There are several distinct strains of this variety differing mainly in season of maturity. The earlier strains have smaller vines and the tubers are fewer in number, paler colored and smoother than the later types. They are also more difficult to maintain or keep free from disease. The earlier types have not produced as large yields, in station trials, as the later types. Until quite recently fields of Triumphs were not uniform as to vine size but certified seed growers and the Experiment Station have, for the past 3 years, been isolating these different types. Starting with the season of 1934, Triumphs will be certified not only as to freedom from disease but also as to season of maturity.

Table 16. Three-year average yields (1931-1933) and 2-year average tuber count in 24 hill tuber lines at the Mountain Substation.

Seasons	No. of Units	Average Cwt. per Acre	Average No. of Tubers per 24 Hills
Extra Early	All discarded		
Early	1	147.5	71.0
Medium Early	4	214.8	114.5
Medium	12	235.5	134.5
Medium Late	12	275.3	142.9
Late	2	227.9	123.5
Very Late	2	274.4	162.0

The Triumph is a round red variety, quite commonly low in starch and not of exceptional quality. The earlier strains seldom show any bloom while the later strains sometimes show a moderate amount. The bloom is pale pink in color. The variety is very susceptible to mosaic, spindle tuber, blackleg and scab and degenerates in 1 or 2 years in the large commercial districts. Certified seed should be purchased every 2 or 3 years. By use of a tuber-unit seedplot and careful roguing the variety can be most satisfactorily and cheaply maintained under dryland conditions or on mountain irrigated farms with enough isolation to keep down the spread of disease by insects. It has another very serious fault in that it "air cracks" if not perfectly matured at harvest time.

This variety produces the best yields of any of the earlies and the later strains will rank right along with the best late varieties in this respect. John Gredig of the Del Norte district in the San Luis Valley raised 1,069.09 bushels on a measured acre in 1931. This is the second highest yield ever recorded in the state. Several other

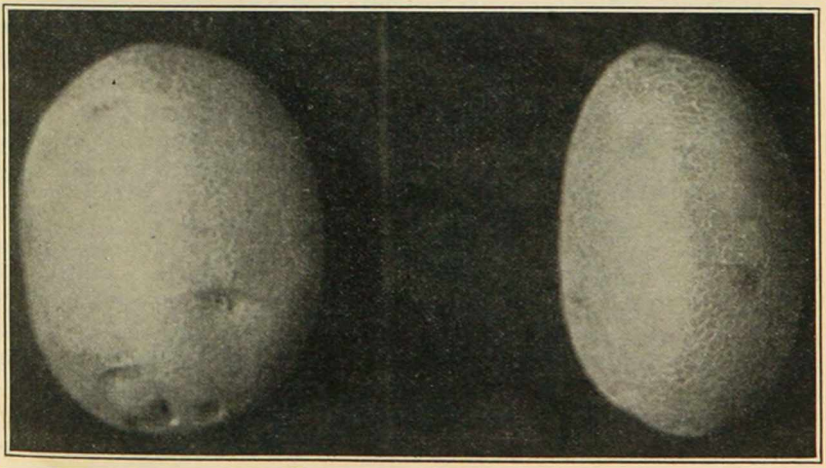

Fig. 13. The Brown Beauty is popular only in the San Luis Valley.

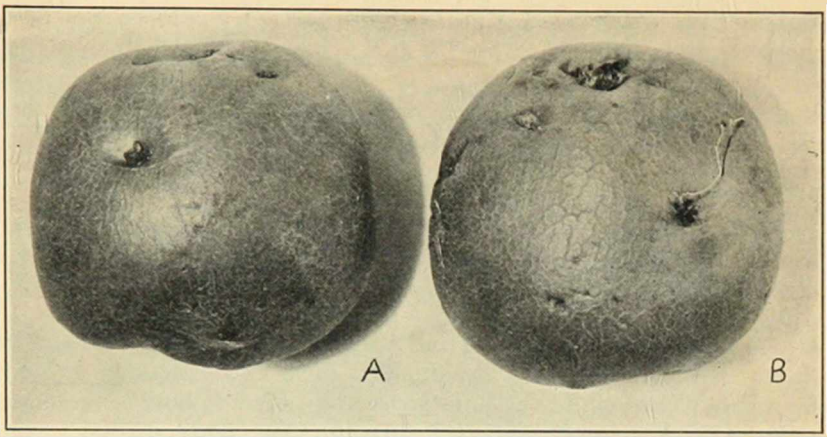

Fig. 14. The Irish Cobbler is the best white early variety.

"600-Bushel Club" memberships have been obtained with this variety.

BROWN BEAUTY (Prolific).—This variety is grown exclusively in the San Luis Valley where it is peculiarly adapted. It has not succeeded in other places largely because of its tendency to set a large number of tubers, 20 of marketable size being not uncommon. Subirrigation is a large factor in its success in the valley. There are around 14,000 acres planted to Brown Beauties. It was until a short time ago the leading variety of the San Luis Valley but this place has now been taken by the Peachblow.

The vines are strong and spreading and under ideal conditions reach 6 feet in length. The Brown Beauty matures earlier than other late varieties. The blossoms are white and profuse if growing conditions are not optimum. Under optimum growing conditions, however, bloom is almost if not entirely absent. The tubers are lightly netted or flaked and a slight pink color more intense at the eyes gives the tubers a slight brownish cast. They are short and oval in shape and moderately flattened.

It is not as susceptible to blackleg as the Peachblow and mosaic is only occasionally found. The chief troubles with the variety are several unidentified diseases possibly of a virus nature. These are tentatively named "heart leaf" (witches broom) the same as in Peachblow, "ragged giant hill" which is very similar to if not the same as "pinto giant hill" in Peachblow. In addition to these two several others are found in Brown Beauty which have not so far been identified in any other variety. These are "small leaved giant-hill" and "pearl type degenerate." These diseases occur in addition to the giant hill already described by Gilbert. Work is now in progress to determine the nature of these troubles.

IRISH COBBLER.—This is an early white variety. The vines are somewhat small, erect and deep green in color. The blossoms are plentiful and the color is pale lilac which fades to white in hot weather. The tubers are more irregular in shape than most other varieties but tend to be round under ideal conditions. This variety has a tendency to be deep-eyed on the heavier soils. It does not set as heavily as the Triumph, 4 to 8 tubers per hill being the average.

There are around 7,500 acres of Irish Cobblers planted in the state. This acreage is mostly in the early districts, the Western Slope and the Greeley, with some plantings on the eastern drylands and in the higher altitudes.

The variety is quite resistant to mosaic but leafroll, spindle tuber and blackleg constitute its chief troubles. It keeps better in storage than the Triumph and is generally higher in starch than that variety. The Cobbler is not represented in the 600-Bushel Club altho unofficial yields of 600 bushels have been reported.

RUSSET BURBANK (Netted Gem, Idaho Russet).—This is the hardest of these varieties to grow. It requires a more fertile soil for profitable yields and an even moisture supply to prevent knobbiness. It will not tolerate a heavy soil or hot weather. It succeeds best between altitudes of 6,000 and 8,000 feet. There are about 3,500 acres planted mainly in the Eagle Valley-Carbondale district and

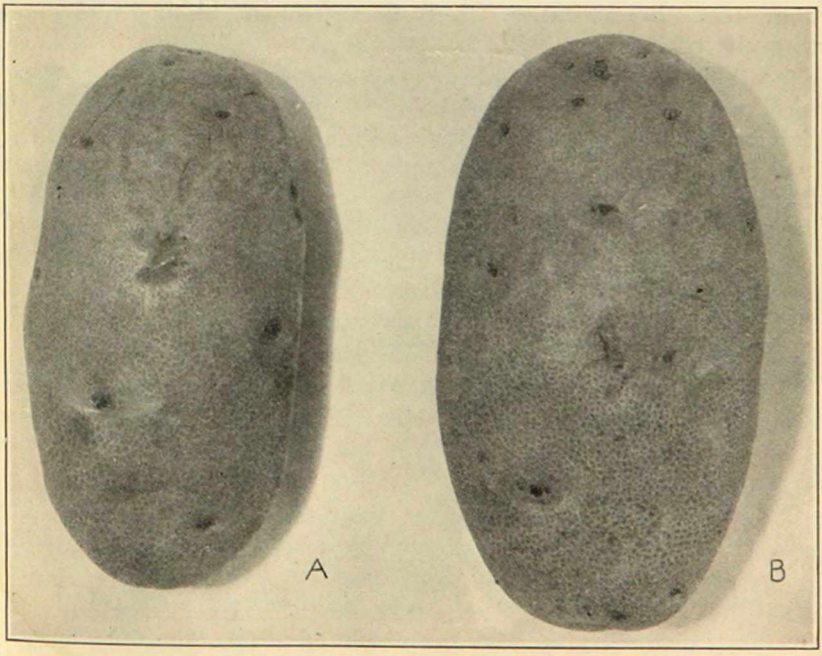

Fig. 15. The Russet Burbank is the hardest potato to grow.

along the Rio Grande River in the San Luis Valley. The Denver market pays a considerable premium for the "Red Soil Russets" produced at Gypsum and Carbondale.

The Russet Burbank is only a little lower in starch than the Peachblow and ranks second only to that variety as a keeper in storage. It is famous all over the United States for its baking qualities.

This variety has a medium-sized vine, yellowish-green in color. The blossoms are white. The tubers are cylindrical in shape with shallow eyes. The skin lacks the brown pigment of other russeted varieties.

The chief cause of degeneration in the Russet Burbank is leaf-roll. Giant hill also gives considerable trouble and mosaic, spindle tuber and witches broom are occasionally found. It seems quite resistant to blackleg and is the most resistant to scab of any variety known, which is the chief reason for its popularity in Colorado.

PEOPLES RUSSET.—This variety is the last of the Pearl group still under commercial production in Colorado. It is identical with the Pearl except that the skin of the tubers contains a brown pigment and is checked or cracked. It occasionally produces a white-skinned sport. Where the seed is good it does not bloom. The set of tubers is light so that on good soils they average larger in size than most other varieties. The tubers are heart shaped and somewhat flattened.

It is grown mostly on heavy gray soils along the rivers in Montrose and Delta Counties and below Glenwood Springs in Garfield County. The brown pigment makes it dark and unattractive. It was in demand by the hotel and restaurant trade because of its size but this demand is decreasing until there are only about 1,500 acres in the state.

Mosaic, spindle tuber and giant hill are its chief troubles. In spite of the large size it attains it is seldom hollow. The Rural, Russet Rural and Bliss Triumph are recommended to replace it. Katahdin also shows much promise as a variety to replace it.

EARLY OHIO.—This is another variety fast disappearing from production in the state. The Cobbler and Triumph are both superior from the growers' standpoint, altho the Ohio may be a little better in quality. There are not over 800 acres being grown.

The Ohio is a little earlier than Cobbler or Triumph but will not, under most conditions, yield with the other early varieties. It will growth-crack and get knobby when the moisture supply is not uniform and often has red streaks in the flesh.

Four distinct types have been isolated at the Mountain Substation based on the same differences as in Triumphs.

Table 17. Yield and number of tubers in different types of Early Ohio. (Average 2 years, 1931-1932.)

Season	No. of Units	No. Tubers per 24 Hills	Cwt. per Acre
Early	2	80	143.3
Medium Early	5	94	168.7
Medium	5	100	174.0
Late	2	119	231.8

KATAHDIN.—This variety is a result of the breeding program of the United States Department of Agriculture. It has been tested by the government for 10 years, at the Mountain Substation for 2 years and at the United States Department of Agriculture Station at Greeley for a longer period. Small quantities have been released to growers in various parts of the state. It has been very enthusiastically received by growers in the mountain districts. It is resistant to mild mosaic but susceptible to leafroll and spindle tuber. Because of these two latter diseases the Greeley station does not recommend it for Eastern Colorado.

The vines are very strong and upright and the leaflets are larger than on any variety so far observed. It blooms profusely. The blos-

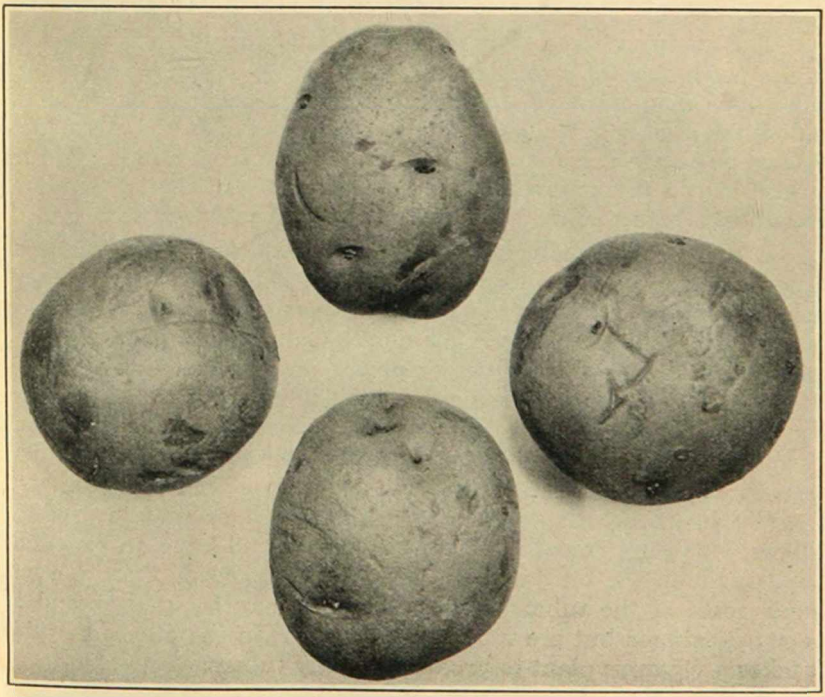

Fig. 16. The three lower tubers are Katahdin; the upper one is Rural New Yorker.

soms are light lilac in color and large seedballs are produced abundantly at the Mountain Substation. The tubers are cream colored, short oval to roundish, with few, very shallow eyes. Tests so far indicate that it is not as high in starch as other late varieties in the state. The yield is about the same as that of the Rural. It produces a very high percentage of No. 1 potatoes.

It has been tried in several districts as follows: San Luis Valley, Greeley, Montezuma County, Montrose County, Delta County, Garfield County, on both heavy river-bottom soil and mountain mesa, Eagle County, Routt County and Teller County. It looks as tho it might replace the Rural and Peoples Russet in Montrose and Garfield Counties.

NEW VARIETIES UNDER TEST.—In addition to Katahdin the station has several other new varieties under test. Chippewa and Golden are United States Department of Agriculture introductions. Warba is the new early from the Minnesota Experiment Station. There are also several new varieties developed by the Greeley Station which look promising and there are some 40 varieties which show promise which were developed at the Mountain Substation.

SEED

The quality of seed planted is one of the most important factors in the production of profitable crops. All of the other practices and conditions may be ideal, but maximum crops cannot be obtained unless the seed is of the best. Good seed is seed that is as free from disease as possible; free from variety mixtures; from a high-yielding strain; grown under favorable climatic conditions; that is firm and sound with sprouts first beginning to show at planting time.

It will be especially noted that no mention has been made of type or appearance in this description of good seed. Both of these depend almost entirely upon the conditions under which the seed was grown. Altogether too much emphasis has been placed on type and appearance and too little emphasis on freedom from disease. The practice of selecting smooth, nice-looking tubers from the bin has actually hastened the degeneration of such varieties as Russet Burbank, Peachblow and Brown Beauty. The grower thought that he was improving his seed and the expense of bin selection was thereby justified. Plants affected with leafroll or mosaic produce tubers which are smooth and of ideal shape and have an excellent appearance in the bin but are not fit to use as seed. On the other hand, some of the tubers in the same bin may be knobby and of poor appearance but are much better seed than the others because it takes a vigorous plant to produce knobby tubers.

Planting what is left after all marketable stock has been sold is altogether too common a practice. This practice always leads to

"running-out" of the seed, but it is surprising how long it sometimes takes under the favorable soil and climatic conditions of this state. The period of favorable prices—1925, 1926 and 1927—completely ruined seed stock in practically all districts of the state, because growers sold everything but the poorest culls, which were used for seed. This seed stock was already well started toward degeneration by this practice following the high prices of 1919. Growers could not be brought to a realization of the diseased condition of this seed during the favorable growing seasons which prevailed thru 1930. Many growers scoffed at the idea of good seed and cite instances of "hog feed" producing profitable crops which, unfortunately, is true in seasons like 1930.

While crops produced from such seed may be profitable in certain seasons, they are not the largest crops that could be produced, so the grower has suffered actual losses in reduced yields, altho he may not realize it. In general, growers have no idea of what good seed is, and the so-called "hog feed" was probably the best seed in the bin. It consisted of the offshape tubers and those that did not conform to the grower's often mistaken idea of type. He had selected for planting those tubers which were smooth, shallow-eyed, weak and diseased. Actual experiments have proved that the good seed was in the "hog feed." The last three seasons have shown the true value of all this so-called seed. Growing conditions have not been quite so favorable and only the best seed produced profitable crops. In view of the above condition, it is more than foolish for any grower to buy seed of which he does not know the disease record.

There is a common belief among growers that changing seed or getting seed which was grown on a different type of soil or under different climatic conditions will materially increase their yields. This is not always true, as certain diseases may be present in the different locations which are not present in the grower's own locality. Growers also had the idea that they could have someone in another district grow a crop from some of their seed, bring it back, and it would again produce a maximum crop. In some cases, the yield was improved the first year by this method, but the seed was back to its former state in the second year. Many times no increase was obtained even the first year and sometimes the seed was actually worse, depending upon the section to which it was sent for the change.

The only cause known at present for degeneration in potatoes is disease, and it is foolish to believe that growing diseased stock in any district of the state will eliminate diseases, which may be present, in one season without any assistance from the grower. Many seed stocks are so badly degenerated that even the best-known methods cannot make them productive. The only possible method of being sure that seed is good is to buy *certified seed.*

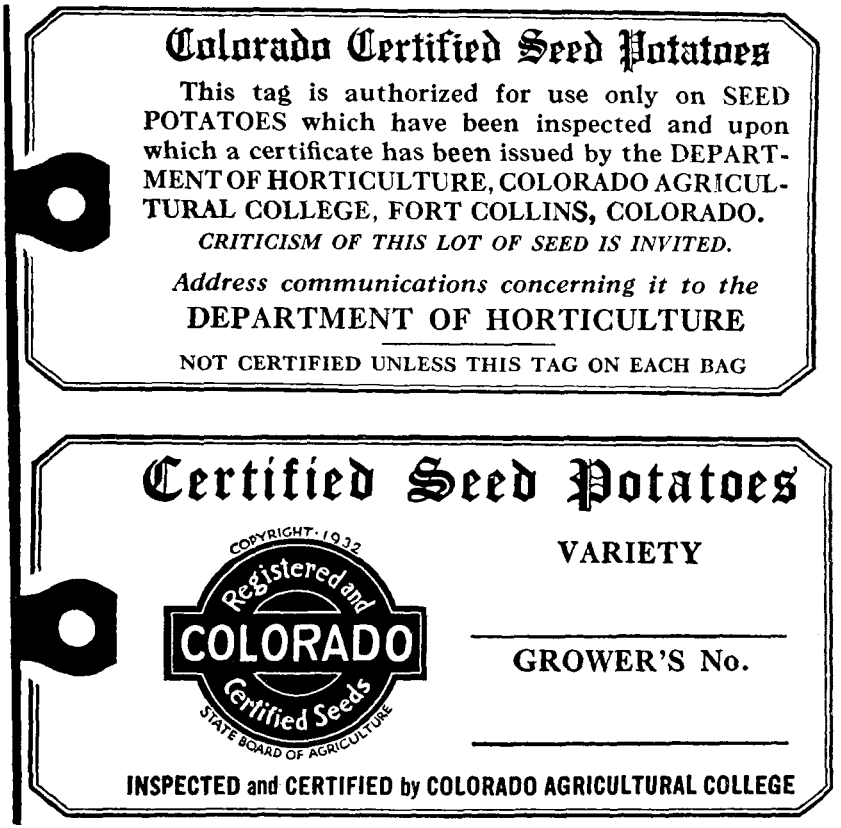

Fig. 17. All seed certified in Colorado must have this blue tag on each sack.

CERTIFIED SEED

Certified seed is seed which has been inspected twice in the field and once in the bin and upon which a certificate has been issued by the Department of Horticulture of the Colorado Agricultural College. Seed is also certified in other states by some one recognized authority. The inspectors are men who have been trained to recognize potato diseases under all conditions. Certified seed always bears the tag which is issued by the certifying authority for lots of seed which meet the requirements for certification. It is the best seed that can be produced, using the modern methods of selection. As mentioned above, most potato diseases cannot be recognized in the tubers. For this reason the two field inspections are the most important for passing on seed stock. The 1934 certification standard is as follows:

Table 18. Percentages of disease allowed on three inspections of potatoes for certification.

Disease	—Percentage of Disease Allowed in— First Inspection	Second Inspection	Bin Inspection
Mosaic	3	2	...
Leafroll	3	1	...
Spindle tuber	2	1	0.5
Giant hill	..	1	...
Other virus-like diseases	2	1	...
Total above virus diseases	4	3	...
Wilts or stem end discoloration	2	1	5
Blackleg	1	Trace	...
Rhizoctonia	..	..	10
Scab	..	..	10
Weak plants	2	1	...
Varietal mixture	2	0.25	...
All diseases combined	5	4	10

In addition to the above mentioned diseases, 10 percent of early blight or psyllid yellows will disqualify fields because these diseases make accurate readings on other diseases impossible, altho they do not themselves have a serious effect on seed stock.

The certified seed program in Colorado is designed primarily to make the best-quality seed available to Colorado potato growers, and have it available as near as possible. Certified seed for the Greeley district is produced in the dryland sections surrounding that district. Certified seed for the San Luis Valley is produced not only in the valley, but also in various high-altitude districts in the state. Certified seed for the Carbondale district is produced at the higher altitudes in that district, and certified seed for the Montrose district is similarly produced.

The value of certified seed has been well demonstrated during the past 3 years. In 1932, 254 demonstrations under the supervision of county agents showed an average of 59.6 bushels in favor of certified seed over common seed. This increase ranged from 10 bushels on dryland, where yields were generally low because of drouth and insects, to 379 bushels in one test in the San Luis Valley.

In 1933, growers of certified seed had an average yield of 260 bushels per acre, which is 104 bushels above the state average. The percentage of certified seed grown on dryland was practically the same as that for the state so the figures can be directly compared. Certified seed growers in Rio Grande County had an average yield of 322.4 bushels compared with 177.3 bushels, the average for the entire county from 1928 thru 1932. Conejos County certified growers averaged 291.7 bushels, while the average for the county was 155.3 bushels. In Alamosa County, the certified growers averaged 316.7 bushels and the county average was 159.2 bushels. The Saguache County average was 163.3 bushels, while certified seed growers averaged 287.3 bushels. Yields of this type are possible in

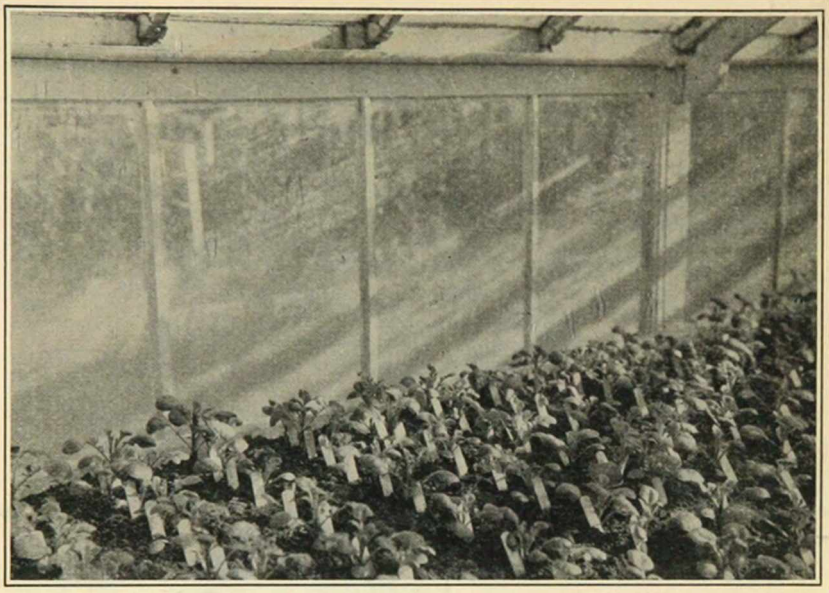

Fig. 18. Tuber indexing foundation seed at the experiment station at Fort Collins.

any of the irrigated districts, provided growers will plant only the best seed and use the best methods of production.

In addition to the field inspections, the Agricultural College is constantly endeavoring to obtain the best strains of seed for certified seed growers. The tuber indexing of all the better strains in the state will soon be completed. Tuber indexing is the most efficient method yet devised for eliminating diseases from seed stock. In this method one eye is cut from a large tuber; the eye is planted in the college greenhouses during the winter months and given a number; the tuber from which it is cut is given the same number and put in storage. Temperatures can be well regulated in the greenhouses so that any diseases present will show up. When the plants are about 10 inches tall they are very carefully examined. The numbers of those which show disease or weakness are taken. The stored tubers are then sorted over and those bearing the numbers of diseased or weak plants are discarded. The remaining healthy tubers are then sent to the Mountain Substation where they are planted in tuber units. They are carefully observed and rogued during the growing season. The best tuber lines are then released to certified seed growers for their seedplots. All growers applying to the college for certification are obliged to send a sample of their seed to the Mountain Substation for a test planting in comparison with all other lots of certified seed. Disease records are taken on

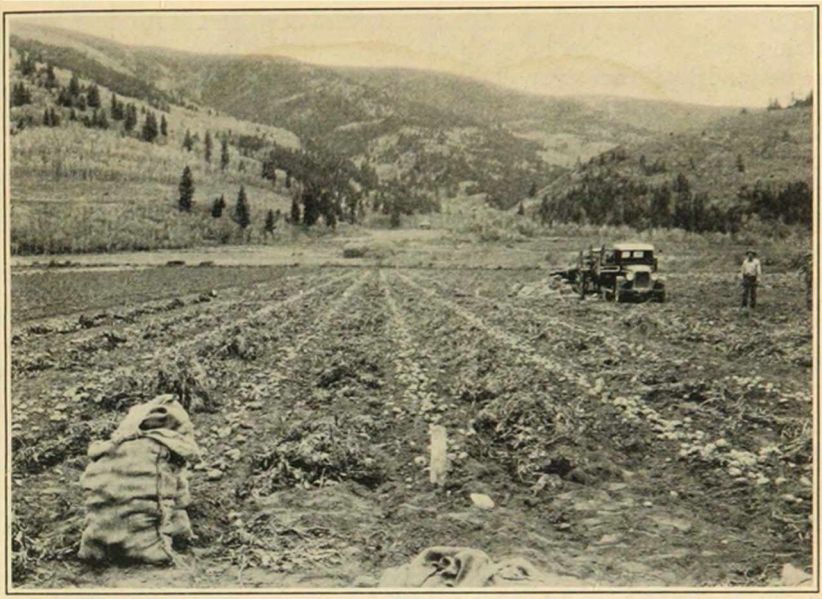

Fig. 19. Harvesting certified sample plots at the Mountain Substation.

these plots and they must meet the regular requirements here as well as in the growers' own fields.

In the early potato-growing districts, growers commonly purchase enough certified seed to plant a seedplot. This seedplot, planted in July, furnishes the seed for the main early planting the following year. This is a most desirable practice and should be followed by

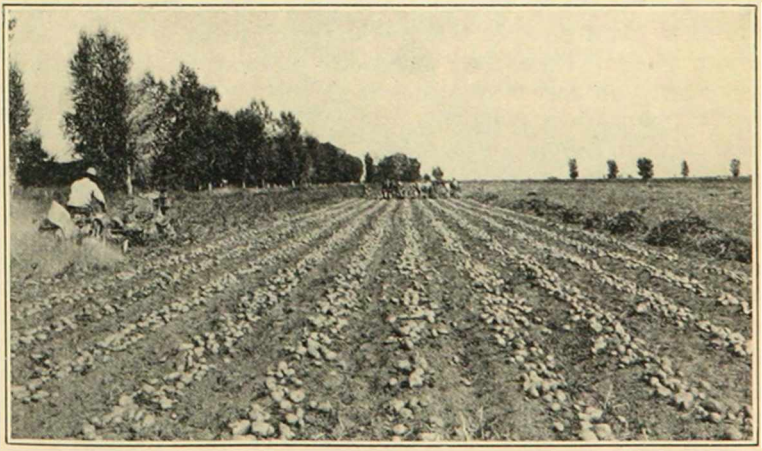

Fig. 20. Harvesting 1,145.17 bushels from a measured acre by L. G. Schutte, the result of humus and certified seed.

all growers. Seed stocks of the late varieties in the main crop-producing sections do not have to be renewed this often, but it is recommended that these growers purchase certified seed every 4 or 5 years.

SEED SELECTION

Most growers in the state have conscientiously sorted over whatever stock they have on hand in the spring and thought they were obtaining some excellent seed if they discarded from 50 to 70 percent. This selection method is generally referred to as bin selection. It has previously been mentioned that some of the diseases which do the most damage cannot be distinguished in the bin. There have been many cases in this state where growers actually hastened the degeneration of their seed by picking smooth, shallow-eyed tubers. Many fields of Peachblows and Brown Beauties in the San Luis Valley contain as high as 95 percent wildlings or heart leaf as a result of this practice. The amount of leafroll in Russet Burbanks in the Carbondale district has been similarly increased.

It is recommended that growers who wish to maintain their own seed stocks learn the potato diseases in the field and pull these diseased plants or rogue during the growing season. If the roguing is properly done, it will not be necessary to sort the seed for planting at all unless rot shows up in it. Profitable yields can be obtained for a much longer period by this method than by bin selection. Growers today would be thousands of dollars ahead if they had spent the money and time necessary for bin selection in roguing their fields during the growing season.

The most efficient method by which a grower can maintain his seed is the tuber-unit seedplot and all certified seed growers are required to plant one. In this method each tuber is cut separately into four pieces. These four pieces are planted in adjoining hills, a space is skipped and four pieces from the next tuber are planted.

Some difficulty has been experienced in the method of planting in this manner. Most growers first opened a furrow with a plow, dropped the seed pieces and then covered them. Many poor stands resulted because the soil dried out while the furrow was open and the pieces were being dropped. There is now a planter on the market which automatically cuts and drops potatoes into the tuber units, but there is none of this type in the state at the present time. Growers on the dryland have worked their corn listers over into two-man planters, and other growers who have the regular two-man planters have obtained very satisfactory results. Two men are used on the rear of the planter instead of one man as in the ordinary planter. The seed has been previously treated and cut part way thru into quarters. The tubers are placed in picking baskets, the quarters of

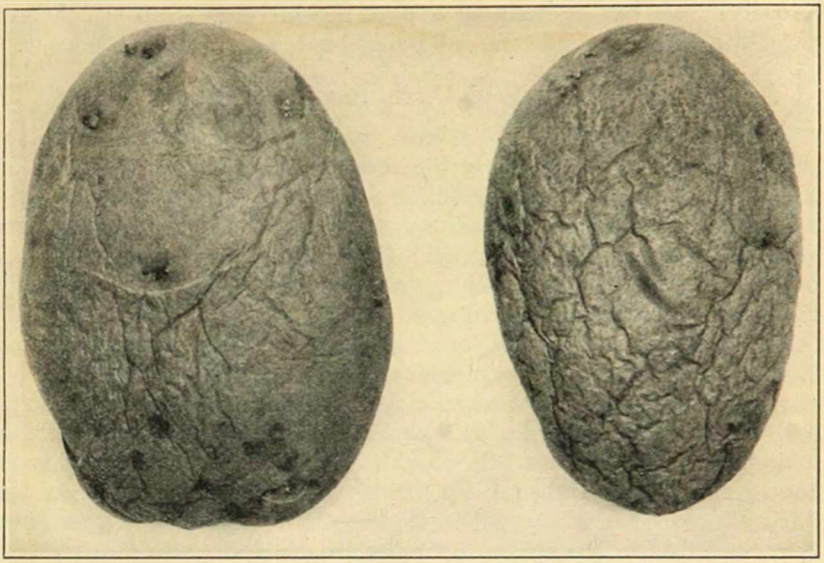

Fig. 21. Excellent appearing seed for the bin selector but from heart-leaf plants.

each tuber hang together. The picking baskets are placed in the hopper of the planter, one man takes a tuber, breaks the four pieces apart and places them in four partitions in the planter wheel. The other man reaches for a tuber, breaks it into four pieces, allows one partition on the planter wheel to go by and places his four pieces in four adjoining partitions. The two men thus alternate in placing the units. The advantage in this manner of planting comes in roguing. All diseased plants are grouped and not scattered over the field. Four diseased plants are more easily distinguished than a single plant. In some cases, only one or two plants of the four show the disease but the rest probably have it also and the entire unit should be removed. This latter condition explains why carefully rogued stock which was planted in the ordinary way sometimes shows disease the next year. In spite of the most careful methods of selection, seed which is absolutely free from disease and maintains this freedom for 3 or more seasons is very rare.

Most of the commercial growers who operate on a fairly large scale will find that it does not pay them to attempt to keep a seed-plot. It must be isolated, it interferes with the rotation, the machinery must be dragged to two fields, and the grower does not have time to rogue it properly. These growers will find it cheaper and more satisfactory to buy enough certified seed for their plantings. Satisfactory results will be obtained in most cases by getting certified seed every 4 or 5 years. Enough for the entire acreage need not

be purchased, but enough for a plot, the increase from which will plant the entire acreage the following year, may be obtained.

KEEPING SEED UNTIL PLANTING TIME

In the definition of good seed given above, it was stated that good seed should be showing the first sprouts at planting time. In some sections it is extremely difficult to keep seed from sprouting until planting time arrives. Some growers in the higher altitudes have no difficulty in keeping Irish Cobblers without sprouting until nearly the first of July. Other growers have difficulty in keeping their seed until the first of May.

It is a well-established fact that potatoes will not sprout below 40 degrees F. Some very ingenious methods for keeping seed till planting time have been worked out by various growers. One grower had a cellar in the side of a hill above 9,000 feet in altitude; there was a spring in the side of this hill which flowed thru the cellar and kept potatoes from sprouting until well into July. Other growers cut ice during the winter and put it in their cellars when the temperature goes above 40 in the spring. Another method suggested is placing the tubers in the light when they begin to sprout. The sprouts will remain short, thick and tough and will not be easily broken off. The vitality of seed is considerably weakened by removing sprouts. The first sprouts which develop are the strongest and develop the best plants. The method of placing seed in the light but not in the sun, is known as greening seed. This is always done in Great Britain. Good seed when greened will develop, as a rule, but one main sprout from the bud-eye cluster unless the tuber is injured. The sprouts should be short and stubby. Tubers with weak sprouts should be discarded. Sorting green-sprouted tubers in this manner serves as a fairly satisfactory basis for seed improvement.

POTATO DISEASES

Growers commonly speak of potatoes running out. This running out is caused only by potato diseases. Potato diseases may be classified into two groups. Parasitic diseases are those which are caused by a known fungus or bacterium which can be isolated and studied in artificial culture. The second group are known as the virus or degeneration diseases and are the ones which cause the running out of potatoes. No organism has yet been isolated in this group.

Parasitic Diseases: Blackleg, wilts, rhizoctonia, scab, early blight.

Virus Diseases: Mosaic, leafroll, spindle tuber, witches broom, curly dwarf.

Other diseases probably of a virus nature: Giant hill, wildling or heart leaf (witches broom), pinto, ragged giant hill, small-leaved giant hill, pearl type degenerate.

All of the above diseases are seed-borne, with the possible exception of early blight.

In addition to the above diseases, a new class is coming to be recognized and is generally called insect diseases. In this group belongs the hopper-burn, or tipburn which is prevalent in the east but has not yet been observed to any extent in Colorado. In this group also belongs psyllid yellows, which has caused so much damage in this state.

The above list of diseases may seem like a large one but this includes only a small part of potato troubles. There are over 90 diseases and troubles of potatoes, and the purchase of certified seed is the principal way in which a grower can reduce losses from them to a minimum. Some of these diseases are carried in the soil as well as on the seed. Blackleg, the wilts, rhizoctonia and scab will live from year to year in the soil and even tho clean seed is planted the resulting crop will become infected from the soil. For this reason a crop rotation is necessary to keep the soil from becoming too badly infected with these diseases.

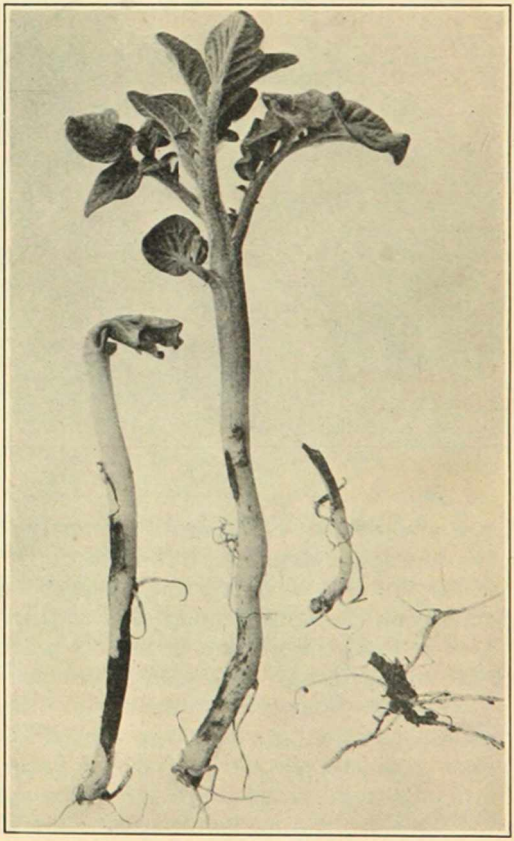

Fig. 22. Rhizoctonia on young plants.

PARASITIC DISEASES

RHIZOCTONIA is one of the most common diseases in the state. It occurs in practically all districts of the state and causes moderate losses every year. On poorly drained soils and in cool, late springs the damage is more severe, amounting in some cases to total losses. Losses in stand caused by this disease are more frequent. It is a fungus and may attack the sprouts on the tuber before they get thru the ground and rot them off, the infection in this case coming from the soil or from the little black specks on the

skin of the seed tuber. The fungus prefers cool weather and does not occur so frequently in warmer growing districts. After the first sprout is rotted off, new sprouts may form at the base of the old, and these may in turn be rotted off or produce weak plants. In case of later attacks, brown, scabby lesions appear on the underground stem, stolons or roots. Severe damage occurs only when these lesions girdle or completely surround the underground stem. In this case the starches and food materials manufactured by the leaves are cut off from the tubers. Many small tubers are formed at the ground line above the lesion to take care of the food which ordinarily goes to the tubers. Small, green, aerial tubers are also found in the axils of the leaves. The plant may become larger and the leaves stiffer in appearance because of the accumulation of starch. Yellowish or reddish discolorations may also appear in the top of the plant. In seasons when there is plenty of moisture toward the end of the growing season, the black specks which are the resting stage of the fungus (sclerotia) are not as noticeable. These black specks, however, become very

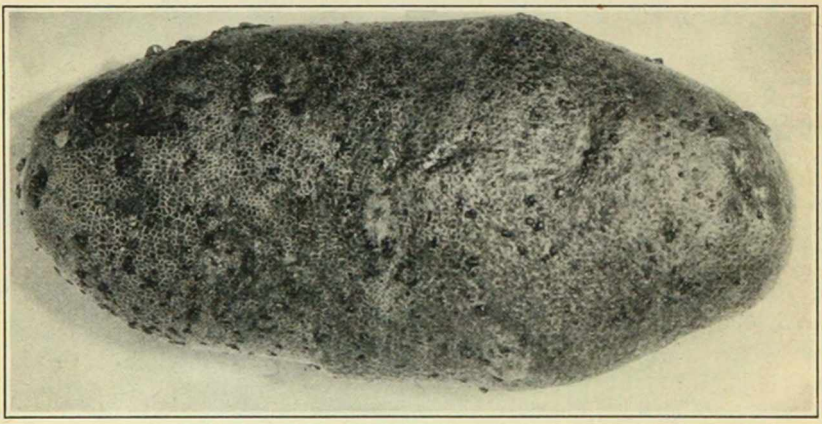

Fig. 23. Rhizoctonia sclerotia on the tuber.

large and detract considerably from the appearance of the tubers when the soil is dry toward the end of the growing season. The control for this disease is treating the seed every year and not planting potatoes on the same ground oftener than once in 5 years. Delaying planting until the ground is thoroly warmed and shallow covering of the seed will also help greatly in controlling this disease.

COMMON SCAB is both seed and soil borne. It is favored by alkaline soil reactions so that it is very difficult to control once it becomes established in a soil. It seems to be worse in dry seasons than those of normal moisture. Authorities are not agreed on just what conditions favor the development of scab. Some maintain that a tight soil favors it; others claim that too much aeration favors it.

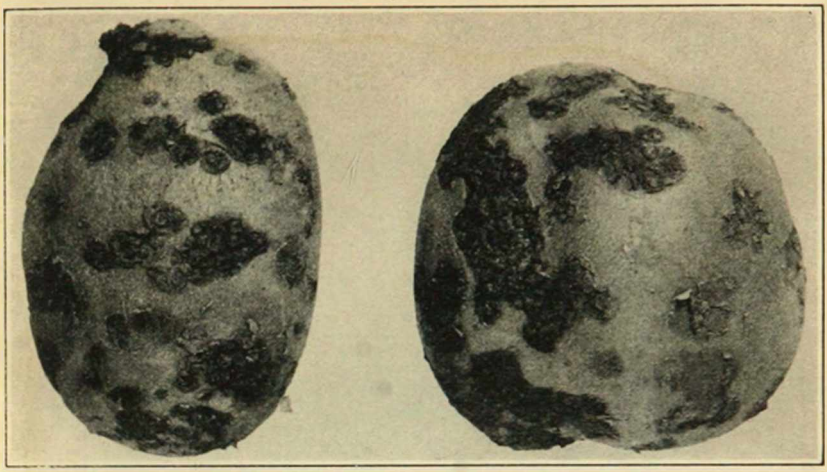

Fig. 24. Common scab.

We are inclined to favor the packed-soil or lack-of-aeration theory. Fresh manure seems to favor its development, but potatoes have been observed growing in an old feed yard in almost pure manure which was *well rotted* and there was not a sign of scab. Scab on the seed is of very little importance as it is quite easily killed by seed treatment. The main objective of the grower should be to prevent infection of his soil by always treating his seed and by a long crop rotation. After the soil has become infected, the only alternative is planting resistant varieties, of which there are very few at present. The Russet Burbank is the most resistant variety but is not suited to dryland. The Russet Rural is second and the Rural New Yorker shows more resistance than the Peachblow, Triumph or Cobbler. None of the early varieties shows any resistance.

BLACKLEG is the cause of more loss to growers in Colorado than any of the other parasitic diseases. It is bacterial instead of fungous in nature. It is also favored by cool, moist growing conditions. The Peachblow, Triumph and Cobbler seem especially susceptible in this state. The disease starts with the rotting of the seed piece. This somewhat wet, slimy rot progresses up the underground stem and in cool seasons sometimes involves the entire plant above the ground. Most districts have trouble with this disease only in the early part of the season, as the coming of warmer weather seems to check its progress.

This disease is especially bad in the San Luis Valley. Fields have been observed in this district in which fully 50 percent of the plants were severely infected. The appearance of the disease is not confined to the early part of the season in this district. It appears continuously during the growing season and growers of seed must

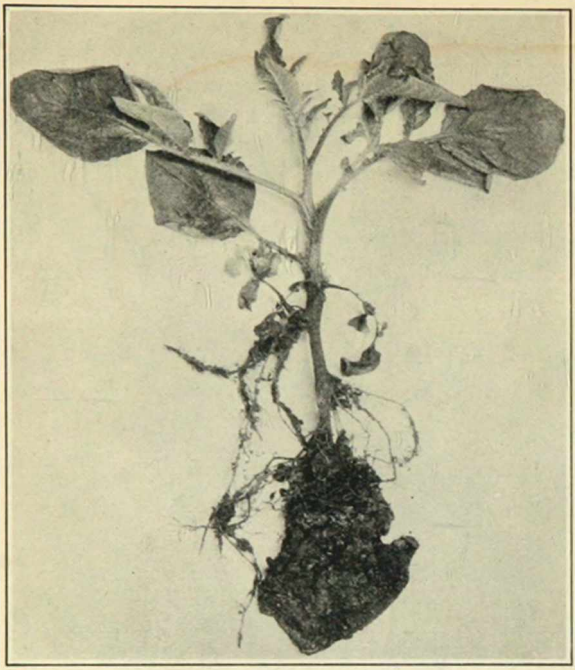

Fig. 25. Rotting of seed piece and stem caused by blackleg.

keep roguing for it until digging time. Tubers produced by plants which become infected after the middle of the growing season are sometimes destroyed by the slimy, foul-smelling rot before digging time. Other tubers from late-infected plants cause foul-smelling, wet rot in the storage cellar. Until recently it was believed that this disease was transmitted only by the seed, but recent experiments in Minnesota have proved that the organism also exists in the soil. The control for blackleg is seed treatment every year, a crop rotation, in which potatoes are not planted on the same ground oftener than once in 5 years and not planting until the soil has warmed up.

FUSARIUM WILT differs from the two above diseases in that it occurs mostly in the warmer growing districts but is sometimes found at the higher altitudes. The chief symptom is a wilting of the vine, which also generally turns a pale yellowish color. It is caused by a fungus which attacks the water-conducting tissue of the plant, thus causing the wilt. The water-conducting tissue is generally killed and turns brown. A longitudinal section of the underground stem in a wilted plant will generally show this brown discoloration. The brown ring in the stem end of potato tubers is also generally associated with this disease, altho experiments have proved that this brown ring is not a reliable indication of infection. Fusarium is not controlled effectively by seed treatment, altho new evidence shows that seed treatment may do some good. The disease is present in practically all soils of the state. Fields which become too wet from over-irrigation are most always ruined by this disease altho growers generally say that they have been scalded. Crop rotation and planting clean seed are the only known methods of control.

EARLY BLIGHT is not as a rule serious in this state. It is not the same as the late blight for which growers in eastern states are obliged to spray. Late blight has never been found in Colorado. Early blight only occurs in seasons when there are frequent showers and cloudy weather. In 1926 there was a rather severe infection of the disease over the state, but generally infections are so light that they are not worth bothering about. The disease is caused by a fungus which attacks the leaves. The infected areas are round, brown, dead-looking spots on the leaves, which if examined closely, show concentric rings like a target.

VIRUS DISEASES

MOSAIC is characterized by a mottling of the leaves. In other words, there are lighter and darker areas of color in the leaf. The mottling is in most forms accompanied by crinkling. The yield of the plants which are infected is lower than that of normal plants. The tubers produced are most always of excellent type and appearance and are invariably selected by growers who make a practice of bin selection. The disease shows best in plants grown at temperatures below 70 degrees F. and may be completely masked by higher temperatures. It is transmitted thru the seed and is carried from infected to healthy plants by insects during their feeding. It cannot be detected in the tubers. The only control is roguing infected plants from the field. Seedplots must be isolated by at least 300 feet from fields which contain any amount of this disease.

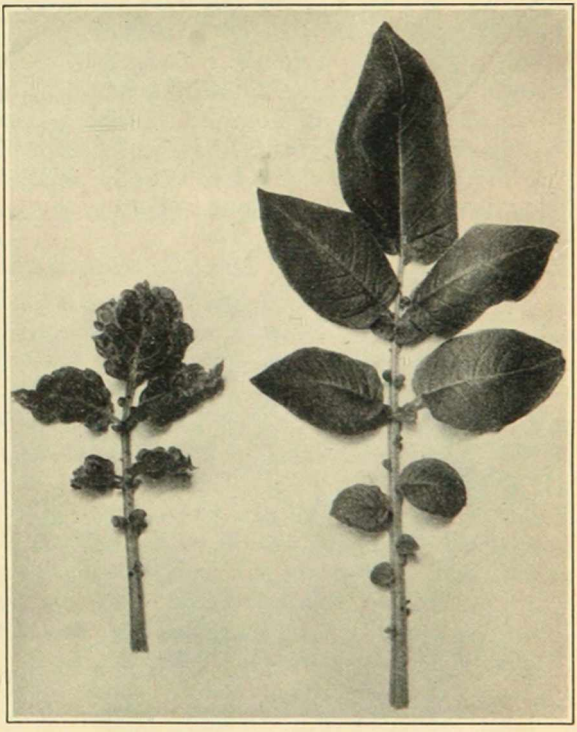

Fig. 26. Mosaic leaf on left, healthy on right.

LEAFROLL is well described by its name. The plants are dwarfed, turn a pale yellowish green, are stiff and leathery and the outside edges of the leaflets roll upward forming a trough with the mid-rib in the center. Tubers produced by plants infected during the current season have brown threads thru the flesh (net necrosis). This net necrosis disappears after the season during which the plant was first infected, so it cannot be used to detect leafroll in the tubers. It is carried from plant to plant by insects. The tubers produced by leafroll plants, two or three small ones to the hill, are generally smooth and of perfect type, so are an ideal prize for the bin selector. Roguing isolated seedplots or purchasing certified seed are the only methods of controlling this disease.

SPINDLE TUBER is also well described by its name. The tubers are elongated, round in cross section, and small in size. The colored tubers are paler in color. The eyes are generally flush with the surface or protruding. The vine is more upright, with the branches growing closer to the main stem and not as spreading as a normal plant. The color of the plant in Triumph is generally darker but is paler in Cobbler and Peachblow. The leaves lose their shine and become dull in appearance. The leaflets are smaller and wavy along the margins. The plants are usually smaller than normal plants. This disease causes a serious reduction in yield. It is spread by in-

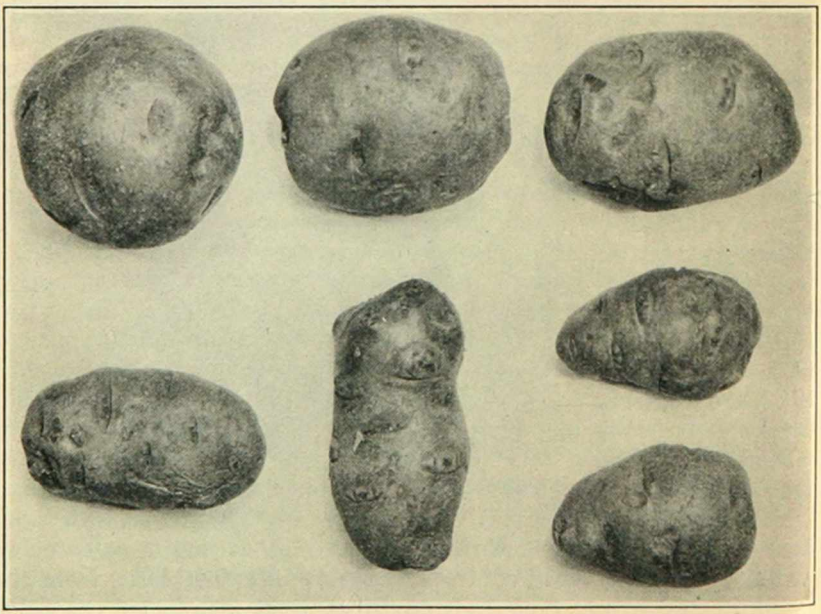

Fig. 27. Three healthy tubers upper, four spindle tubers lower.

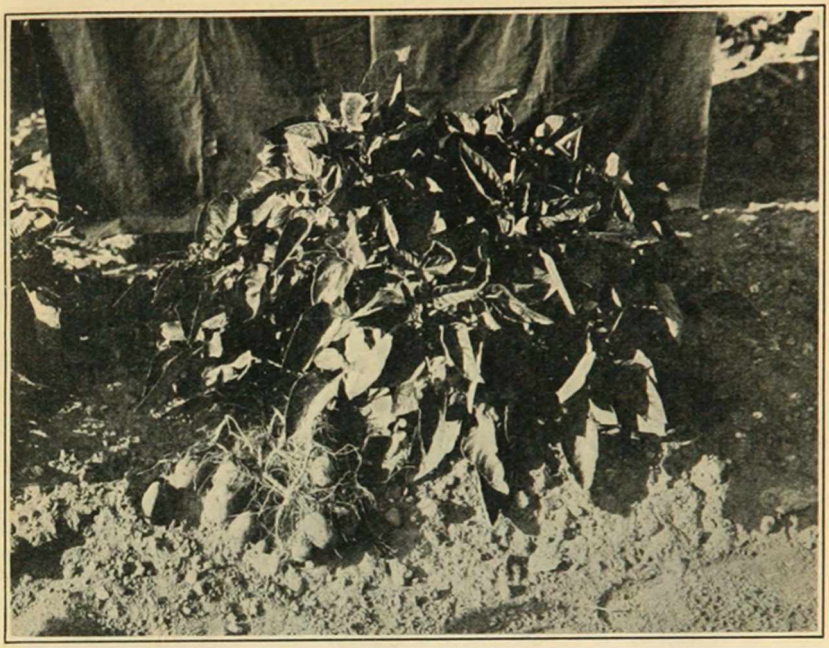

Fig. 28. Heart leaf, wildling or perhaps witches broom on Brown Beauty.

sects, the cutting knife and pick planters. It can be controlled thru roguing, isolated seedplots or purchasing certified seed.

CURLY DWARF occurs but rarely in the state. More has been observed in Brown Beauties in the San Luis Valley during the last 2 years than anywhere else. The name describes the disease. The plants only get about 6 inches tall and are just a tuft of curled, deformed leaves. It has not been prevalent enough to cause any serious losses so far.

WITCHES BROOM.—The plants are a mass of fine weak stems with much-dwarfed leaflets. Extremely large numbers of tubers are produced, few of which reach one-half inch in diameter. When tubers infected with this disease are allowed to sprout the result is a mass of very weak small sprouts. This is known as "spindle sprout."

GIANT HILL cannot be diagnosed until the latter part of the growing season. Until this time the plants appear normal. Late in the season, however, they show up because they are taller than other plants and bloom longer than other plants. They also show up after the first frost because normal plants will be frosted down but the giant hills will remain upright and green. They produce large, coarse tubers and generally yield more than normal plants. The tubers are most generally abnormal in shape and are not desirable from a market or seed standpoint. It was first described as a

phase of spindle tuber. Field roguing and certified seed are the only controls for this disease.

WILDLING OR HEART LEAF (witches broom) has apparently not been previously described in American potato literature but seems to have received considerable attention in Great Britain. The plants are somewhat dwarfed and produce a number of weak secondary stems. The terminal leaflet is short and heart-shaped instead of long and slender as in the normal leaflet. The first pair of lateral leaflets are much reduced in size. The second pair are very small and the third pair are usually entirely absent. The folioles are also generally missing. An abnormal set of tubers occurs, averaging around 40 per hill. The tubers are somewhat longer and flatter than the normal and are extremely shallow-eyed and smooth. The disease has occurred exclusively in the San Luis Valley, where fully 50 percent of the tubers from these plants go thru the screen and are used for seed. The condition is perpetuated by the tubers. The method of transmission is unknown and all attempts artificially to transmit the condition have so far met with failure. Field roguing and certified seed are recommended for control.

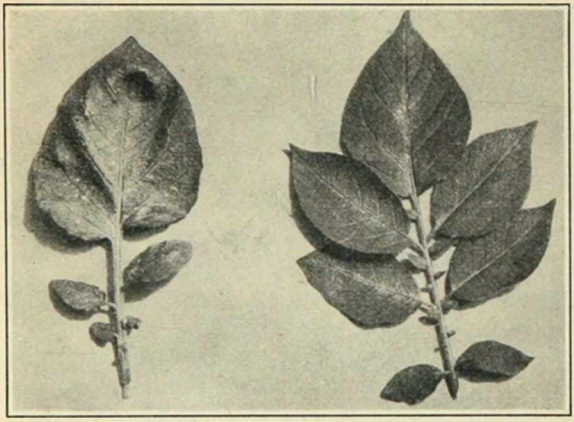

Fig. 29. Heart leaf left, normal right, on Brown Beauty.

PINTO is a condition observed in the Peachblow variety. The plant is larger and more rugged than the normal. It blossoms more profusely and sets seedballs, which does not occur in normal plants. The leaflets are somewhat shorter than the normal and are more sharply pointed. The color is more of a gray-green and is dull, whereas, the normal is bluish-green and shiny. The tubers are abnormal in shape, being round in outline, short and deep eyed. They are very hard and difficult to cut. Instead of being the pink color of the normal, they are blotched red and white, hence the name. Cases of solid red tubers and solid white tubers have been observed but they are quite rare. The yield is lower than on normal hills. The nature of this condition and the method of transmission are not known. The control is field roguing and certified seed.

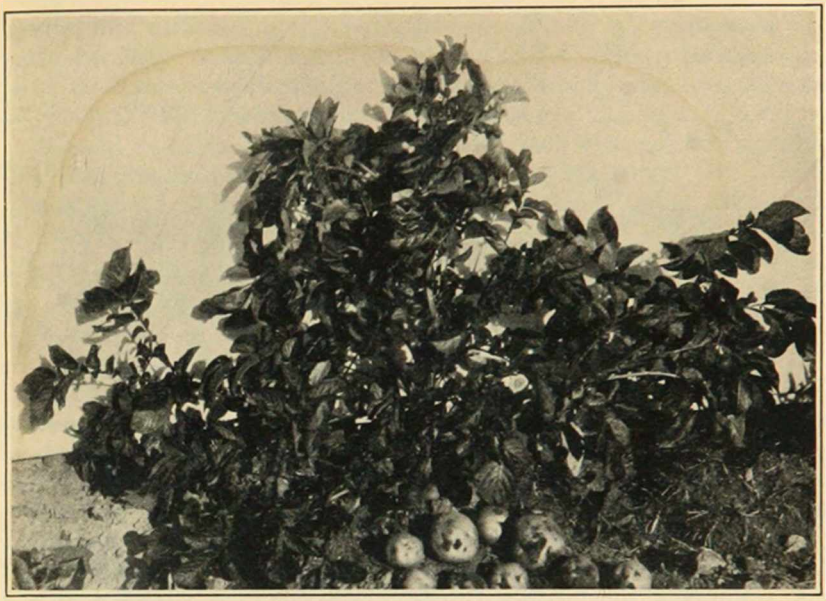

Fig. 30. Ragged giant hill of Brown Beauty.

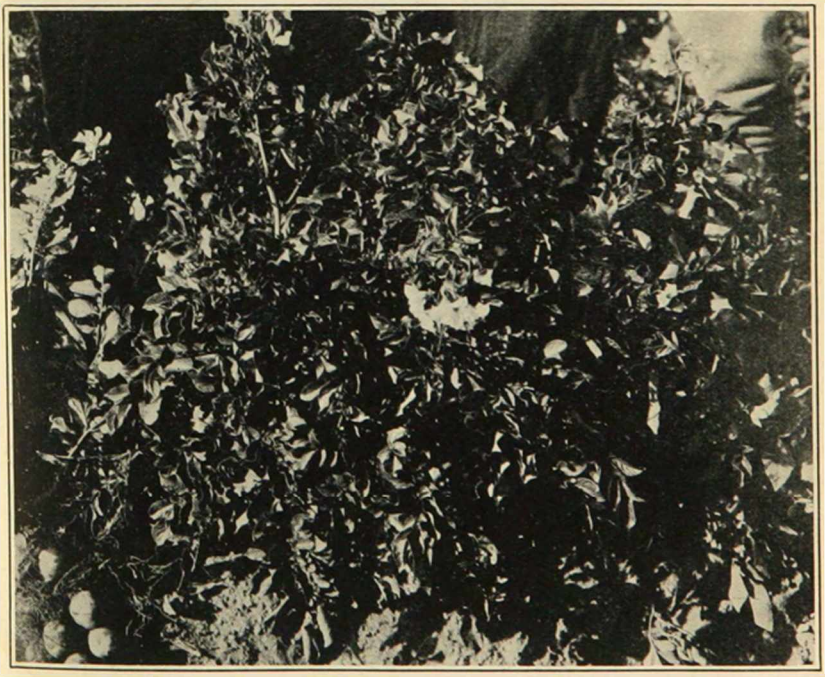

Fig. 31. Small-leaved giant hill of Brown Beauty.

RAGGED GIANT HILL occurs only in Brown Beauties and is possibly closely related to the pinto condition above described. The vines are deeper colored than the normal with considerable pigment on the stems, which is entirely absent in the normal. The leaflets are shorter and broader than the normal and dull in color instead of shiny. The plants are larger, bloom later into the season, and produce seed balls. The tubers are round, deep eyed and more nearly white than the normal. The pink color in the bud-eye cluster is more intense than in normal tubers. The nature of the trouble and its method of transmission are unknown. The method of control is field roguing and certified seed.

SMALL-LEAVED GIANT HILL has been observed only in Brown Beauties. The plant is very much larger than the normal and paler colored. The leaflets are considerably smaller and dull colored. The plant continues to bloom after normal plants are thru. The tubers are rough, flattened and deep eyed. The pink color in the eyes is all that is left to identify them with the Brown Beauty variety. The yield is lower than in normal plants. The nature of the trouble and the method of transmission are unknown. Control is certified seed and roguing in the field.

PEARL TYPE DEGENERATE has also been observed only in Brown Beauties. Both the vine and the tubers resemble the Pearl very closely. The condition also somewhat resembles the wildling condition described above, but the set of tubers and yield are not abnormal.

Fig. 32. Pearl-type degenerate in Brown Beauty.

The nature of the trouble and method of transmission are not known. It is possible that this is simply the Pearl variety formerly grown in the valley mixed with the Brown Beauty. Field roguing and certified seed are recommended to eliminate this condition.

SEED TREATMENT

Treating seed before planting has been neglected by most growers in the state. The result of this negligence is everywhere in evidence. The Carbondale district was formerly the home of the Peachblow potato. The soils have become so badly infected with scab that the Russet Burbank is now the only variety that can be grown on many farms in this district. There is hardly a farm in this district or in the San Luis Valley on which a crop free from rhizoctonia can be raised. Longer rotations and seed treatment every year will be necessary to keep this disease from ruining these districts. There are only three potato diseases which can be controlled by seed treatment. These are: Blackleg, rhizoctonia, and scab. There is also now some evidence to show that fusarium or wilt may be held in check to some extent by seed treatment. Growers have often been misled as to the value of seed treatment, believing that seed stocks would remain productive indefinitely, provided the seed was treated. *The virus diseases are in no way affected by seed treatment.*

METHODS

There has been a great change in the materials used for treating seed during the past few years. Growers became very impatient with the old 1½-hour to 2-hour soak methods and could hardly be blamed for not using them. Today instantaneous dips remove the major objection to seed treatment and there is hardly an excuse for a grower neglecting it at the present time. Two instantaneous methods are now in general use.

THE ACID-MERCURY DIP is constantly gaining favor as one of the most satisfactory methods. Dissolve 6 ounces of mercuric chloride (corrosive sublimate) in 1 quart of commercial hydrochloric (muriatic) acid. Add this to 25 gallons of water in a wooden container. A 50-gallon wooden barrel is a very suitable container. Mercuric chloride is a deadly poison and will corrode metal of any kind. The concentrated acid should also be handled very carefully. The diluted solution is not strong enough to injure the hands. The potatoes should be emptied into wooden crates or wire baskets treated with asphaltum paint and then placed in the solution. It is not advisable to treat in sacks as the sacks weaken the solution and the solution weakens the sacks. The tubers should be well dried after treating. Cut seed cannot be treated by this method. The tubers should be allowed to remain in the solution for 5 minutes, but are not in-

jured by leaving them as long as 40 minutes. Enough unused solution should be kept on hand to keep the container at its original level. Twenty to thirty sacks can be treated, then the solution should be discarded and a new one made up. Growers who plant late during warm weather should reduce the stength of this solution as instances of poor stands have been observed when the recommended strength of the solution was used.

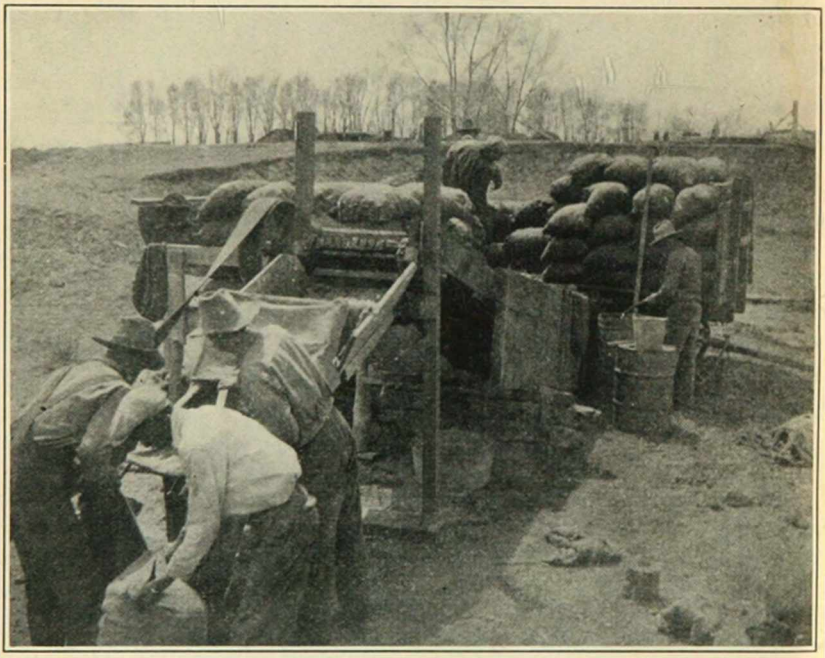

Fig. 33. Treating seed on a large scale.

THE ORGANIC MERCURY COMPOUNDS, of which there are now several on the market, are known as instantaneous dips. These materials formerly failed to control rhizoctonia but new formulas have been developed by the manufacturers which now seem satisfactory for the control of this disease. These materials are not corrosive and may be used in metal containers. One pound will treat from 20 to 30 sacks. Picking baskets are generally used and the operator simply makes sure that all the tubers are wet. The tubers should be thoroly dried as soon as possible after treating. Cut seed may be treated with these materials. This procedure is especially recommended when cut seed is planted in the San Luis Valley. Any seed that is worth planting is worth treating.

IRRIGATED VS. NON-IRRIGATED SEED

Does irrigation water have any effect on the vigor and vitality of seed potatoes? This question has been the subject of many heated debates in the potato industry. At first glance, the subject seems absurd. How could running water down a furrow affect seed any more than water from above? Many experiments, however, in years past have seemed to prove that irrigated seed was inferior. The results in practically all cases, however, were based on yields of seed stocks *of different origin* and an *unknown virus disease content.* The knowledge of virus diseases was very meagre when most of these experiments were run so it is not surprising that they were not often mentioned in connection with results. The conviction that irrigated seed is inferior is so firmly intrenched that even today irrigated fields are barred from certification in some states. Such has never been the case in Colorado, however.

The Idaho station pointed out in 1920 that there was no difference in irrigated and non-irrigated seed when "good, healthy tubers true to variety were used."

Edmundson of the Greeley station concludes:

"The experimental results with the Rural New Yorker, the leading commercial variety of the Greeley (Colorado) district, indicate that irrigation water has little or no effect on the vigor and vitality of seed.

"From 1921 to 1924, inclusive, irrigated seed grown under a varying number of light applications of irrigation water produced very similar yields.

"From 1926 to 1929, inclusive, comparisons made of seed receiving different numbers of light irrigations, seed grown without irrigation, and seed grown in wet, seepy soil resulted in similar yields.

"Seed grown for 15 years under irrigation produced yields comparable with non-irrigated seed."

Similar conclusions have recently been reached in Montana and Nebraska.

Any difference in the yielding ability of seed stocks is due mainly to diseases. Evidence is also accumulating that strains of superior yielding ability may arise as sports or mutations. Under dryland conditions plants are farther apart, insect carriers of disease are not as numerous, and the harder growing conditions tend to eliminate weak and diseased plants or they show up so plainly that they are more easily rogued. These facts explain the superiority of non-irrigated seed in earlier tests. Isolated seedplots planted in tuber units with occasional tuber indexing make it possible to produce just as good seed under irrigation as under dryland conditions.

WHOLE VS. CUT SEED

Cut seed is planted in all sections of the state except the San Luis Valley. Growers in the valley have for years made a practice

of saving the small tubers from their commercial crops for seed. Many fields did not contain a single normal plant as a result of this practice, and it is surprising that any yield at all was obtained. Many of these fields averaged 75 to 100 sacks per acre in spite of the disease, so growers were convinced that there was nothing wrong with the seed. Some growers are much too easily satisfied. No grower should stop trying to better his methods until he averages 200 sacks or more per acre in any irrigated district in this state. Many growers in the San Luis Valley are convinced that they cannot obtain stands from cut seed. In 1932 quite a number of seedplots were planted with cut seed in Saguache and Rio Grande Counties. In a good many of these seedplots where the cut seed had been properly handled there was no difference in stand between the whole and cut seed. Cut seed should not be planted until the soil has warmed up. It should be planted immediately after cutting and should be treated with one of the organic mercury compounds for best results. It

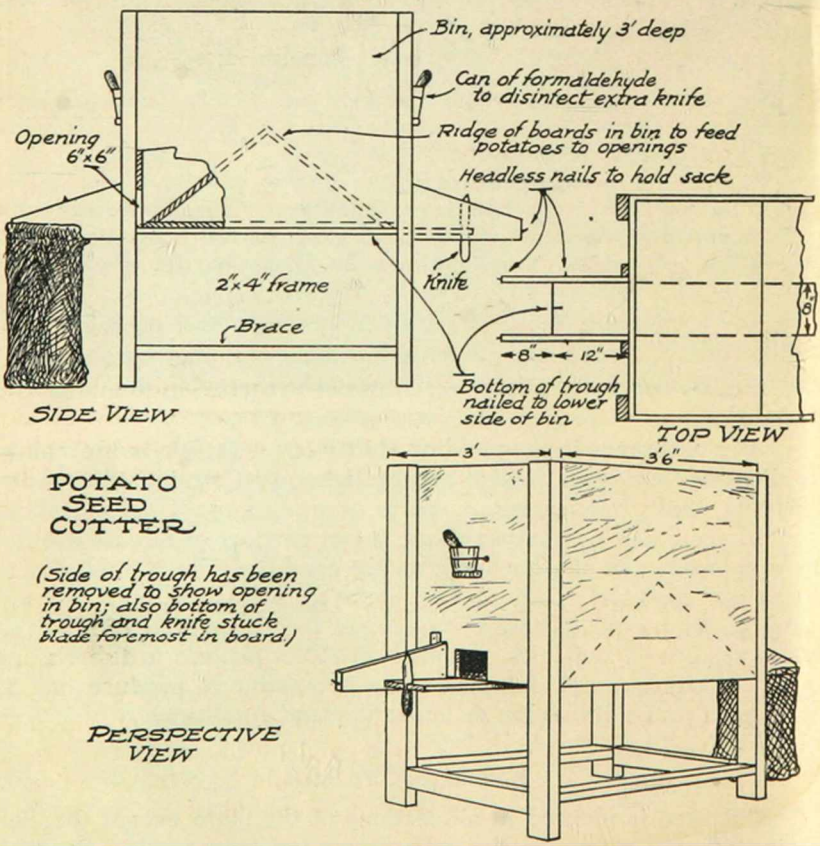

Fig. 34. This cutting box makes cutting a lighter job.

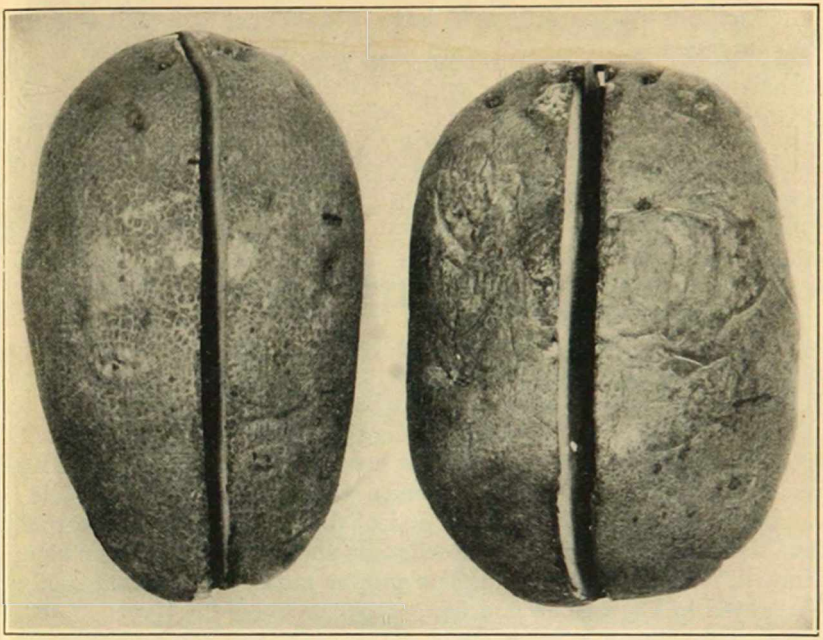

Fig. 35. The first cut.

should not be planted as deeply as whole seed. The chief disadvantage in planting whole seed as it is done in the San Luis Valley, is that weak or diseased hills produce more small tubers than the strong, healthy hills. Over a period of time, the strong, healthy hills would be eliminated because they produce no small tubers which will go thru the screen in favorable seasons. It must be admitted, however, that planting whole seed is cheaper than planting cut seed. If growers in the valley wish to continue this practice, they should plant as late as possible, using tubers as large as 6 ounces and space the plants as close as possible in the row. This seedplot should be planted with certified seed.

CUTTING SEED

There are very few growers who cut seed to the best advantage. A good many hold the knife in the hand and whittle wedge-shaped pieces from the tuber any place there happens to be an eye. These pieces do not handle well in the machine planter and have so much surface exposed that they readily dry out. The skin of a potato tuber is cork and is one of the most efficient coverings developed in the plant world. As much of the skin should be retained on each seed piece as possible and each seed piece should be blocky so that it will not readily dry out.

Machines for cutting seed have been developed, but are not recommended for most Colorado varieties. If the Peachblow is cut into four equal pieces, the stem end piece on the left side of the tuber will not contain an eye. The same is also true to a certain extent of the Brown Beauty. These two varieties have very few eyes. Seed pieces should be cut so that they average 1½ to 2 ounces in size or about as large as a hen's egg. A board for holding the knife will make it possible to cut seed much more rapidly than holding the knife in the hand. The hopper illustrated in Figure 34 is used at the Mountain Substation and is very satisfactory. In cutting seed it is important to remember that the strongest and best sprouts come from the bud-eye cluster, so the first cut should always be made from the bud-eye cluster thru to the stem of the tuber, except in long varieties such as Russet Burbank. As many cuts may then be made crosswise as desired, holding the two halves of the tuber together during this process. Some growers follow the wrong practice of discarding either the stem end or the seed end, or both. While it is true that the eyes at the stem end of the tuber are more dormant than those at the seed end, experiments show that there is no significant difference in the yield. The proper method in cutting seed is illustrated in Figures 35 and 36.

In some districts of the state, it is advisable to plant the seed as soon after it is cut as possible. In most of the mountain districts, however, it may be allowed to set for some time without any dam-

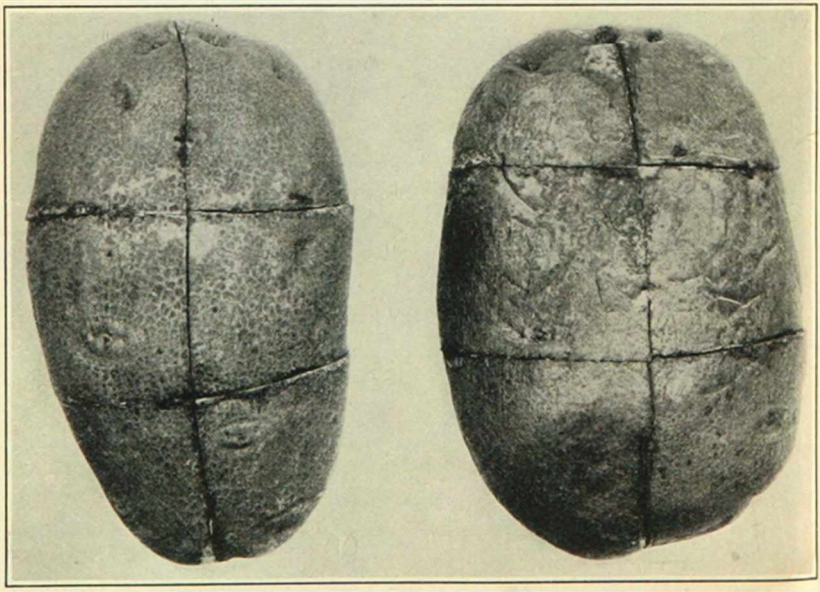

Fig. 36. Finishing cutting into blocky pieces 1½ to 2 ounces each.

age, provided it is not piled so deeply that it will heat. The practice of sprinkling freshly cut seed with lime or with sulphur is of doubtful value. Road dust would serve just as well to absorb the excess moisture. Cut seed has been allowed to stand for as long as 2 weeks without any damage at the Mountain Substation.

The amount of seed required per acre for various sized seed pieces and various planting distances is given in Table 19.

Table 19. Pounds of seed required per acre with various planting distances and sizes of seed pieces.

Spacing Between Rows in Inches	Spacing Between Plants in Inches	No. of Pounds per Acre — 1 Ounce Size	1¼ Ounce Size	1½ Ounce Size	1¾ Ounce Size	2 Ounce Size
30	8	1,632	2,040	2,448	2,856	3,270
	10	1,308	1,638	1,956	2,286	2,616
	12	1,092	1,362	1,632	1,908	2,178
	14	936	1,164	1,398	1,632	1,866
	16	816	1,020	1,224	1,428	1,632
32	8	1,530	1,914	2,298	2,682	3,066
	10	1,224	1,530	1,836	2,142	2,448
	12	1,020	1,278	1,536	1,788	2,040
	14	876	1,092	1,314	1,530	1,752
	16	768	960	1,152	1,344	1,536
34	8	1,440	1,800	2,160	2,520	2,880
	10	1,152	1,440	1,728	2,016	2,304
	12	960	1,200	1,440	1,680	1,920
	14	822	1,026	1,236	1,440	1,644
	16	720	900	1,080	1,260	1,440
36	8	1,362	1,704	2,040	2,382	2,724
	10	1,086	1,362	1,632	1,902	2,178
	12	906	1,134	1,362	1,590	1,812
	14	780	972	1,164	1,362	1,554
	16	678	852	1,020	1,188	1,362
	18	606	756	906	1,056	1,212
42	18	516	648	780	906	1,038
	24	390	486	582	678	780
	30	312	390	468	546	624
	36	258	324	390	456	516
48	18	456	570	678	792	906
	24	342	426	510	594	678
	30	270	342	408	474	546
	36	228	282	342	396	456

PLANTING

Many of the difficulties encountered in Colorado could be avoided if the crop were properly planted. Seed is quite often planted too deeply and in some cases too early. In either case it lies in cold ground, germinates slowly and is subject to attack by the soil-borne diseases, "rhizoc" and blackleg. In other cases the seed is not properly cut or the planter is in poor repair and a poor stand results. In 1910 a survey of the state showed the average stand to be 70 percent. The average stand today is very little better. It is hard to understand why a grower will painstakingly prepare a seedbed, cultivate and irrigate with the utmost care and yet be satisfied with

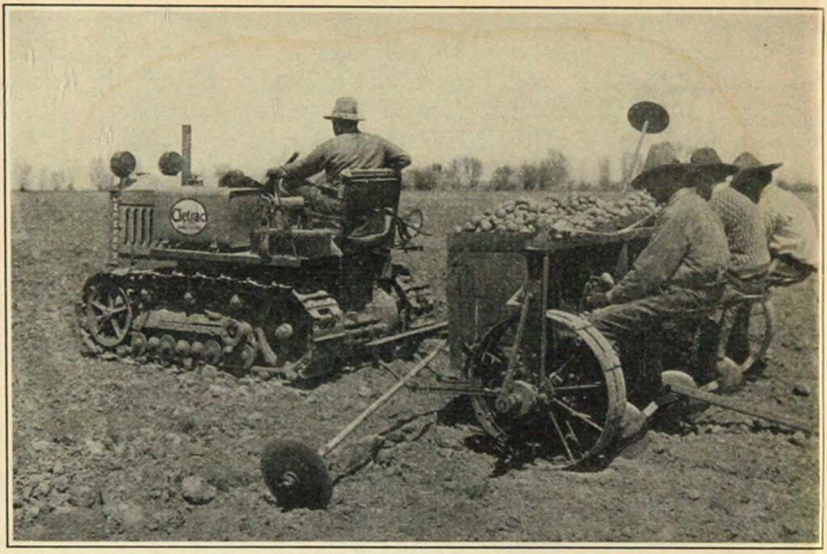

Fig. 37. Three-row cup-type planter and men to correct the feed.

from 70 to 80 percent of a yield. Experiments have proved that the hill on each side of a skip will make up one-quarter of the loss of one hill. So when a skip consists of more than one hill, only one-half of the yield of one hill is made up and the others are a total loss.

DATE OF PLANTING

Potatoes are planted from the first week in April to the middle of June in Colorado, depending upon the district. Some growers in the San Luis Valley plant as early as the last week in April. The soil is still cold, germination is very slow, and many of the plants contract rhizoc and blackleg which seriously injure the stands and the yields. It is very doubtful if anything is gained by planting Brown Beauties before the first week in May and experience has shown that Peachblows are much better planted after the middle of May. When certified seed is used, Triumphs may be planted as early as the Brown Beauties. Blackleg is a more serious problem in Peachblows and Triumphs and this disease is not prevalent when the soil is warm enough to insure immediate germination. Some growers have practiced planting a seedplot as late as June 28 in order to obtain small tubers for planting. The object has not been attained because growers who are painstaking enough to go to this trouble have fertile soils and their efforts have resulted in market-sized tubers in spite of the late date.

The Greeley district has gone to the other extreme in planting late to escape damage from fusarium, flea beetles and Colorado

potato beetles. The Greeley potato station has concluded after 5 years of experimentation that the Rural New Yorker plantings made on May 20 and June 2 tended to be superior to those made June 12 from the standpoint of both yield and maturity. They also concluded that the yields of Triumphs increased with the lateness of planting, the plantings of June 12 producing much larger yields than the earlier ones. In the mountain districts plantings are generally made between May 10 and June 1. In the early districts plantings are made as early as the last week in March altho it is doubtful if it is advisable to plant before the first week in April. Crops planted as late as April 15 are often ready to harvest as early as those planted the last week in March.

DEPTH

The San Luis Valley is probably one of the few districts in the United States where there is a tendency to plant too deep. Potatoes are sometimes planted as deep as 7 inches below the level. This deep planting has the same effect on the crop as planting too early. Five inches below the level is sufficiently deep even in the sandiest soils in this district, and 3 to 4 inches is sufficient on the heavier soils. In most other districts the planting is not deep enough. In order to test the depth of planting the ridge left by the planter should be leveled off even with the surface of the soil before planting; then dig to the seed piece and measure the distance below the level. It should be 3 to 4 inches in heavier soils and as much as 5 on the lighter types. Shallow planting tends to increase the amount

Fig. 38. Picker-type planter.

of sunburn as the tubers are all set above the seed piece and sufficient soil to cover them cannot be obtained when the seed piece is at the surface of the ground.

PLANTERS

There are three types of planters used in Colorado. Each type has its advantages and disadvantages. The cup type is almost exclusively used in the San Luis Valley. It is well adapted to handling whole seed, but is not well adapted to cut seed because the corners on the cut seed wedge into the cups and the piece does not fall out when the cup turns over to go down the tube. Some growers use this planter as an assisted feed type, pulling as many as three of them with a tractor and having a man to correct the feed on each planter. It is rather difficult to use this planter in this manner, as the length of chain and number of cups between the seed hopper and the tube are so short that a man must be very active to place a seed piece in an empty cup. He is also in constant danger of catching his fingers when the cup turns over into the tube.

The picker-type planter is probably more generally used than any other because of its cheapness of operation. There is no means by which a seed piece on every picker is insured, altho this machine is now nearly mechanically perfect and there are very few misses with seed properly cut and in uniform-sized pieces. The pickers jabbing into the flesh of the seed pieces are an excellent agency for the spread of any diseases seed might contain. Spindle tuber and blackleg, especially, are effectively spread in this manner. In some of the mountain districts the seed has kept so well and is so brittle

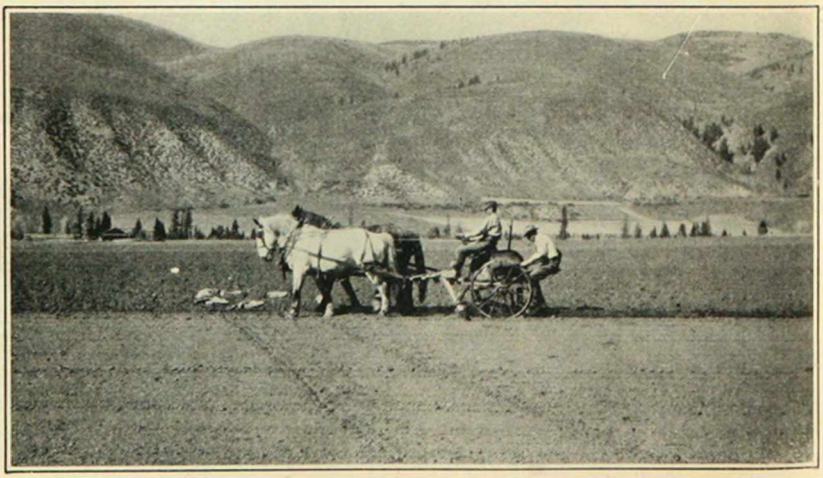

Fig. 39. Two-man or assisted feed planter.

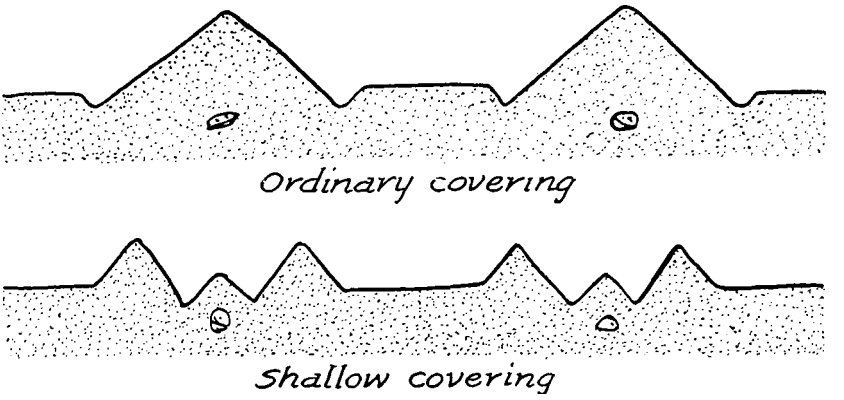

Fig. 40. Ordinary covering and shallow covering.

that when a picker sticks into it, it splits and a missing hill is the result.

The third type of planter is known as the two-man or assisted feed type. A conscientious man on the back end of this planter can consistently secure a 99 percent drop. It handles both whole and cut seed equally well, provided the seed pieces are nearly uniform in size. It can be readily adapted to any size seed piece and any spacing desired. Standard equipment on this planter is now a shallow covering device which places the seed piece in the furrow and puts just a small amount of soil on top of it, making it necessary for the young plant to come thru only 2 inches of soil instead of 6 to 8 inches as is the case when the seed is covered with a ridge. The soil surrounding the seed warms up more quickly, earlier germination is secured, and injury from rhizoc and blackleg lessened. Harrowing crossways will level off the ground once germination has gotten well under way. A spacing device is also obtainable for this planter which insures a variation of not over half an inch between plants in the row, thus insuring a more uniform-sized crop. This same machine may also be obtained in a picker type. Any of these planters may be obtained in one, two or three-row units.

SPACING

The chief consideration determining the distance between rows is the amount of soil necessary to cover the tubers. The closest possible spacing with present machinery is probably 30 inches. This close spacing is advised in the early districts so that the plants will more nearly cover the rows and shade the soil. In general, planting distances are between 34 and 36 inches and in a few cases 38-inch rows are used. The distance between plants varies with the variety and the fertility of the soil. In Bostwick Park it is necessary to plant Rural New Yorkers as close as 9 inches in the row in order to keep

the size down within reason. It is also necessary to plant Peachblows as close as 8 or 9 inches in some districts to prevent growth crack. Cobblers are also generally planted as close as 10 inches on good soils. The Russet Burbank, on the other hand, is seldom planted closer than 14 inches and is sometimes planted 16 or 18 inches apart in the row. Table 20 gives the number of hills per acre, with perfect stand, for the various spacings.

Table 20. Number of hills per acre if there is a perfect stand.

Rows Apart, Inches	8 in.	10 in.	12 in.	14 in.	16 in.	18 in.	24 in.	36 in.
30.....	26,136	20,909	17,424	14,935	13,068	11,616	8,712	5,808
32.....	24,502	19,602	16,335	14,001	12,251	10,890	8,168	5,445
34.....	23,061	18,449	15,374	13,178	11,531	10,249	7,687	5,125
36.....	21,780	17,424	14,520	12,446	10,890	9,680	7,260	4,840
42.....	18,669	14,935	12,446	10,668	9,334	8,297	6,223	4,149
48.....	16,335	13,068	10,890	9,334	8,168	7,260	5,445	3,630

CULTIVATION

Cultivation is one of those potato-growing practices for which no definite rules can be made. The practice varies with the type of soil, the growing district, the opinion of the farmer, whether the potatoes are irrigated or non-irrigated, and whether an early or late crop is being grown. Growers will find it profitable, however, to harrow with a spike-tooth harrow, with the teeth laid back, two to three times between the time the crop is planted and the plants reach a size of 2 to 3 inches. In cases where the soil is packed by the planter, a cultivation with the regular cultivator should be given as soon as the planting is finished. The number of cultivations thru the growing season varies even among the best growers. Records from the 600-Bushel Club show variations of from 2 to 10 cultivations.

The important point in cultivating is to cultivate deeply and close to the plants while they are small and getting farther away from the plants as they become larger and their root systems expand. A new implement called the chisel has been used for the earlier cultivations in the San Luis Valley. There is one chisel point between each pair of rows and generally four of these points are fastened to one frame and drawn by a tractor. These chisel points penetrate as deeply as 16 to 18 inches, and do an excellent job of loosening the soil. This system is successful in this district because of subirrigation, but can hardly be recommended where furrow irrigation is practiced, because of danger of washing this loose soil and also because of the difficulty in getting water thru without getting the soil too wet.

HILLING

Two methods of culture are followed in this state, depending

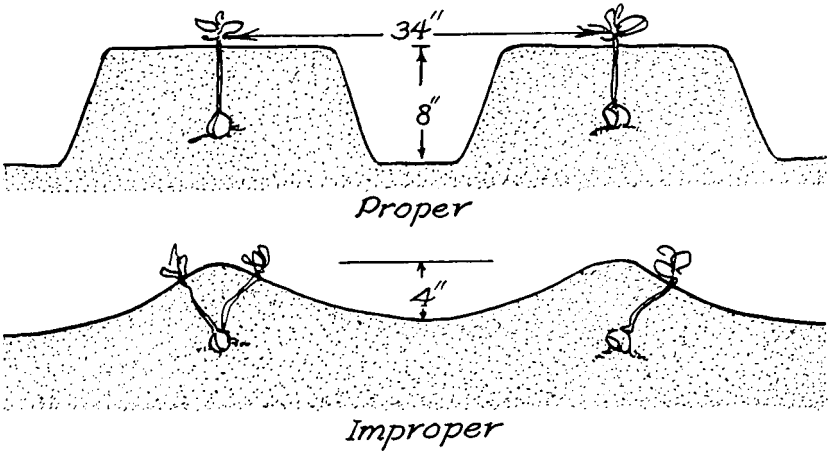

Fig. 41. Good ridges should be broad at the top.

upon whether the land is irrigated or non-irrigated. The level system of culture is most generally followed on the non-irrigated land, as moisture is conserved by this method. Hilling generally begins with the first cultivation after the plants are too large for the spike-tooth harrow. The shovels on the cultivator are set so that the soil is thrown toward the plants. This smothers the weeds starting in the row and makes a ditch for irrigating. Fenders are generally provided to prevent the small plants being covered during the earlier cultivations.

During all the cultivating operations the grower should keep in mind the ideal type of ridge, which is as broad at the top as possible. There must also be enough soil on top of the ridge to cover all of the tubers which will be developed later. The size and shape of this ridge is of vital importance in preventing sunburn. The large yields secured in Colorado under irrigation make the prevention of sunburn a difficult problem, which can be largely solved thru the proper formation of this ridge. Tubers not only come to the surface of the ground but quite often protrude from the sides of the ridge. This protrusion can only be kept at a minimum when the ridge is broad at the top. Inverted V-shaped ridges are to be avoided.

These ridges should be formed quite early; otherwise, the plants will be considerably damaged thru the cutting of roots in the formation of the ridges. As soon as the plants begin to interfere with cultivation, the plants should be "laid by." The last one or two cultivations are made with disc hillers or winged shovels. The disc hillers probably make the best-shaped ridge. It is necessary to have the furrows which carry the water between these ridges deep enough so that water does not come in contact with the plants. In the warmer growing districts it is not advisable to ridge until the

Fig. 42. The first cultivation should be given when the plants are 6 to 8 inches tall.

cool weather of late summer arrives, as more surface is exposed and the soil temperature greatly increased by high ridges, and there is also a greater loss of moisture by evaporation. Many new growers make the mistake of not "laying the plants by" early enough and do more damage than good in attempting to ridge after the plants have covered the rows.

It is important to remember that the best way to cultivate is to thoroly prepare the seedbed. The operations above described are only for controlling weeds, making ditches in which to irrigate, and to provide sufficient soil coverage for the tubers. Cultivation does not increase the yield but may actually decrease it. Two to four cultivations are plenty in most districts. In some districts, especially in the San Luis Valley, farming systems (or lack of systems) leave the land so foul with weeds that cultivation with machinery does not eliminate them and it is necessary to pull them by hand.

IRRIGATION

Potatoes should be irrigated whenever they need it, regardless of whether they are not yet up, 6 inches tall, or in bloom. They should be kept growing continuously and not checked by lack of water at any time. The experienced grower can tell by the color of the vines when potatoes need water. The beginner should dig into the row to about 6 inches below the seed piece. The soil at this depth should form a ball when squeezed, which retains its form when pressure is relieved and leave the hand slightly moist.

There is no question more frequently asked than, "How often should I irrigate?" It is unfortunate that there is no definite rule

on this point. The number of irrigations depends first on the water-holding capacity of the soil. Soil which is sandy requires more irrigation than a heavier type. Second, organic matter in the soil increases the water-holding capacity and cuts down the number of irrigations necessary. Third, the drainage and slope of the land also influence the number required. Fourth, the weather also has an important bearing on the number of irrigations, more being required in hot, clear weather than in cool, cloudy weather. Fifth, varieties like Cobbler with small vines that do not shade the ground require more irrigation than varieties like Rural, Russet Burbank or Peachblow.

The wilting of plants during the middle of the day is not necessarily an indication of a need for water. The potato is a cool-season plant and its root system is not large enough to take care of excessive transpiration from the vine during hot weather. The potato makes its best growth between 45 and 80 degrees F. Temperatures both above and below, check its growth. The appearance of vegetative shoots from the sides of the ridge is not an indication of poor seed or mistakes in irrigating, but is generally caused by high temperatures. The stolon, instead of forming a tuber, keeps growing and emerges from the ridge as a leafy shoot.

Members of the "600-Bushel Club" irrigate from 3 to 14 times, with the average 6.64 times.

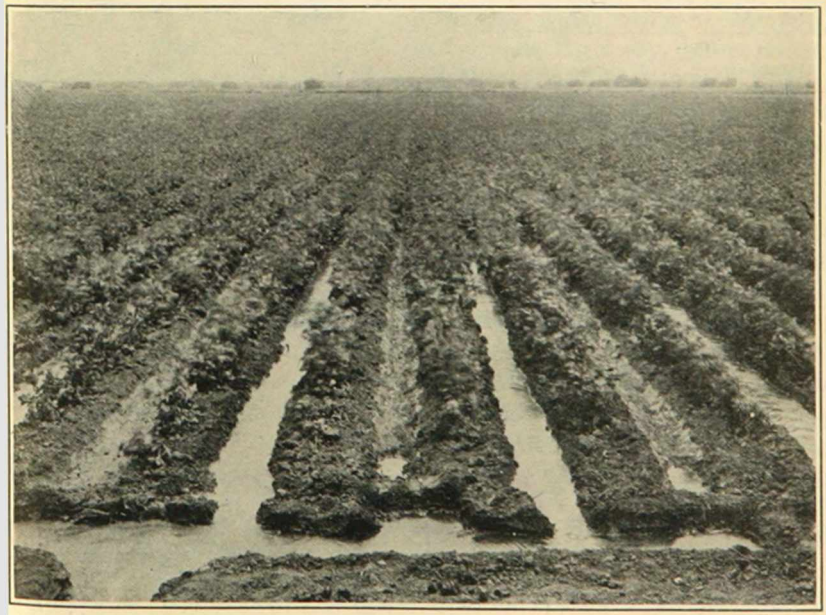

Fig. 43. Irrigating in alternate rows.

"How much water should I apply?" is the second question asked. There is also no definite answer to this question, as some soils take water or "sub" much more readily than others. In some cases a run of 8 hours or less is sufficient; in others a run of 48 hours is required. In some cases soils take water so readily that it is run in only every other row one time and in the missed rows the second time over. The water should not be allowed to run after the "sub" reaches the shoulder of the ridge, and it should be allowed to run until the soil under the seed piece has received sufficient moisture. Too much water is as bad or worse than too little. The growth is checked and in warm weather fusarium always attacks plants which get too wet. The soil packs and the percentage of culls is increased. The tubers do not get air, the lenticels enlarge and turn white, and the quality and appearance of the tubers are greatly damaged.

There is probably more controversy over when to start irrigating potatoes than any other point. Some growers insist that they should not be irrigated until they are in bloom; others wait until the vines turn "black" and wilt; others pay no attention to the stage of growth but irrigate when the soil gets dry enough to require it. Experiments lasting 7 years at the Greeley station prove that withholding water till blooming or wilting lowers yields and increases culls.

Table 21. *Average acre yields 1919 to 1925 at Greeley.

Time of Irrigation	Primes	Culls	Total
When needed	291.3	21.9	313.2
Blooming	266.5	23.5	290.0
Wilting	210.2	26.2	236.4

*U. S. D. A. Technical Bulletin 118. Edmundson, W. C., 1929. Studies in Time and Rate of Irrigating Potatoes in Colorado.

It is very important that the soil does not become dry enough to check the growth of the plants, not only early in the season when yields are chiefly affected, but particularly after the tubers are set. If checked at this time, the quality and appearance always suffer, the skin sets and the tubers begin to mature. Some varieties like Triumph, Rural and Brown Beauty get long and ill-shaped; others like Early Ohio and Russet Burbank get knobby, and still others like Peachblow growth-crack when irrigation is resumed. This is generally known as second growth.

In heavy soils which are apt to puddle when irrigated, the furrows should be deep (below the seed piece). The soil around the tubers will then remain loose and friable and permit the tubers to develop more normally. The soil will not be so apt to stick to the tubers. A cross section of furrows of the proper type is shown in Figure 46.

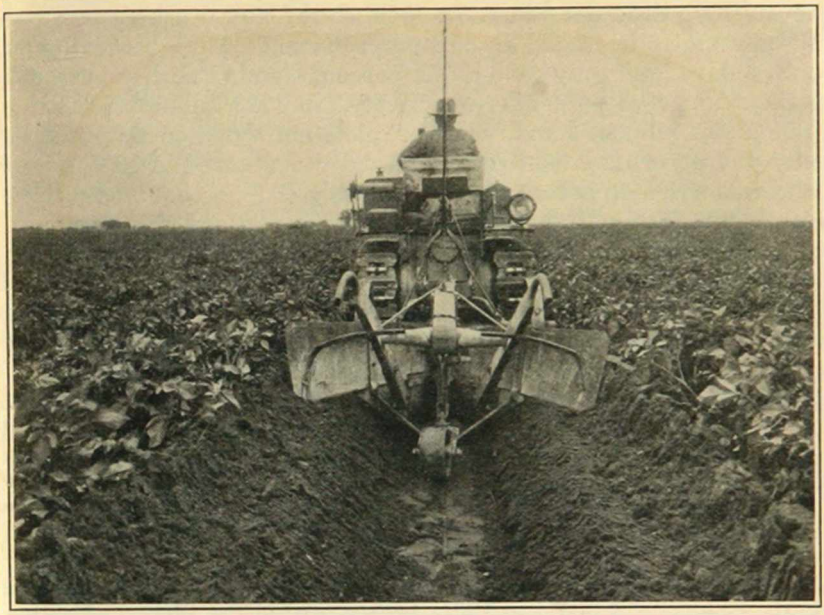

Fig. 44. Making the subditch.

IRRIGATING UP

Most authorities condemn the practice of irrigating up potatoes. It will never be necessary if proper precautions are taken before planting. In the case of fall plowing, the ground is generally so dry that it must be irrigated before it can be plowed. If this ground is worked down as early as possible in the spring, sufficient moisture to insure germination is usually assured. In the case of spring plowing, the ground in the dryer sections should always be irrigated or "flooded" first. This will provide sufficient moisture for germination.

In spite of these recommendations and precautions, there will be occasional cases where growers will be confronted with the problem of whether or not to irrigate up. Seed will sprout in dry soil, but the roots will not develop without moisture and the plants will not come thru the ground. In case the soil has dried out from winds or other causes the grower will not hesitate to irrigate up. Extreme care must be taken to prevent flooding any part of the field, as this will cause the seed to rot. The furrows should be a little deeper than the seed is planted, so the moisture will go to the seed piece, but the soil on top of it should remain as dry as possible. Alternate rows only should be used if the soil subs readily.

The Greeley station has made notes* on the effects of irrigating

*U. S. D. A. Technical Bulletin 118. Edmundson, W. C., 1929. Studies in Time and Rate of Irrigating Potatoes in Colorado.

up during 4 different years. In 1919, Rural New Yorkers irrigated up on June 18 averaged an 85.4 percent stand. Those not irrigated until 5 days later only gave a 67.1 percent stand. Peerless gave 86.2 percent and 64.5 percent, respectively. In 1922, plots irrigated up gave a 95.7 percent stand, whereas, plots not irrigated up produced only 84.7 percent. A 95.7 percent stand was secured in 1925, where land was irrigated before plowing but only 60.3 percent was secured by irrigating up as rain followed the irrigation and the lower end of the field was flooded. Yields were obtained on comparable plots in 1926 in addition to stand counts. The germination on the plot irrigated up was 96.3 percent and the yield was 435.9 bushels per acre. The plot not irrigated gave 91.8 percent of a stand and a yield of 411.31 bushels per acre or 24.57 bushels less than the plot irrigated up. In the second series the figures are, for plots irrigated up, 96.5 percent stand and 482.9 bushels per acre against a stand of 91.6 percent and 431.4 bushels per acre for the plot not irrigated up. The increase for irrigating up was 51.56 bushels per acre.

SUBIRRIGATION

This method of irrigation is confined to parts of the San Luis Valley where the water table is high and there is plenty of water. No water is run in the rows as in the furrow method. One or two rows in each 20 or 40 are skipped in planting and a large ditch is run in this space when irrigation is to start. (Fig. 44.) Water is run in these ditches and the water-table raised until capillarity brings

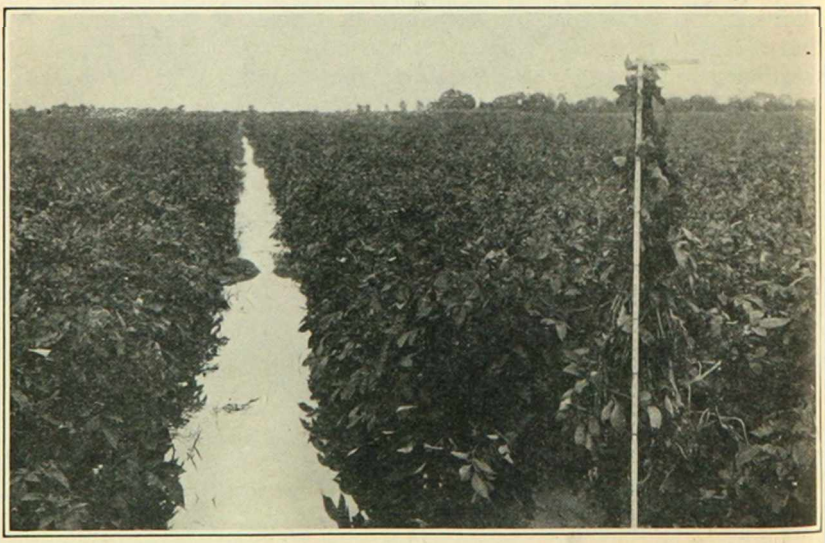

Fig. 45. Subditch. Plants 54 inches tall on August 6 and growing an inch per day. Note the absence of bloom. L. G. Schutte farm.

the moisture to the surface. (Fig. 45.) The water table is then maintained at this level by regulating the flow of water in the ditches.

This method has a good many disadvantages. It takes an enormous amount of water to "get the sub up." During the past 3 dry years growers have been unable to "get it up" or have "lost it," which resulted in serious damage to crops. A grower is not in absolute control of the moisture in his soil, as his neighbors' activities in irrigation influence his sub. Many fields are "drowned out" by careless or excessive use of water, and heavy rains after the sub is up mean disaster. Its advantages are, that it is economical of time and labor, an even amount of moisture is supplied thruout the season *if properly handled* and *if the neighbors cooperate*, soil temperatures never become excessive and the soil is never packed, puddled or crusted by this method.

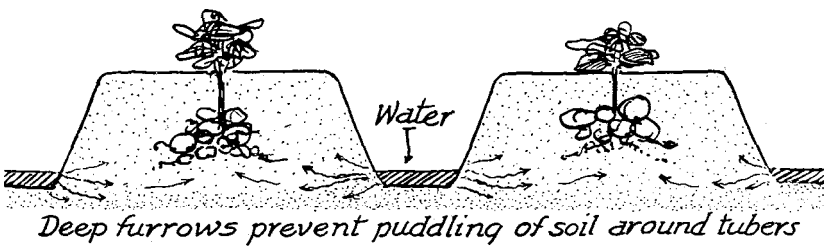

Fig. 46. The water should enter below the seed piece to prevent puddling the soil around the tubers.

In 1931, many growers dug wells to save their crops. They could not pump water from the ground, return it thru the sub ditches and expect to raise the water table, altho some tried. Others were obliged to furrow irrigate for the first time in their lives. Many failures resulted. In some cases the water was run the entire length of half-mile rows in every row, water was allowed to run 24 hours, and in most cases the seed was so badly diseased that it would not have produced a full crop under any conditions. The almost total absence of organic matter was also shown by the way these soils "ran together," baked and crusted. Furrow irrigation was immediately condemned and many growers since have allowed their crops to "burn up" rather than furrow irrigate with what little water they had. The peculiar thing, however, is that during this same period some of the most progressive growers have averaged 250 sacks per acre and furrow irrigated every year. These growers put in two or more head ditches in the half-mile and made three runs. They only irrigate every other row and put the water thru as fast as possible, then change it. They plant *certified seed* and all feed sheep so their soils are well supplied with organic matter. They have all been surprised by the smaller amount of water required to produce a crop.

WHEN TO STOP IRRIGATING

Irrigation should cease in time for the tubers to mature before digging. This will vary from August 20 to September 10. Too much soil will stick to the tubers if it is wet at digging time. The Greeley district, in particular, must give more attention to producing clean, mature stock.

SUMMARY OF RECOMMENDATIONS

1. Irrigate potatoes as often as they need it.
2. Do not let growth become checked by lack of moisture at *any time* during the season or a loss in yield and quality will result.
3. The water should run until the sub comes together under the seed piece, which will not require over 48 hours on any soil.
4. Potatoes should be irrigated up if the soil is dry.
5. Plenty of organic matter will not only increase the water-holding capacity of the soil, but keep it from puddling, baking and crusting so badly after irrigation.
6. Runs much over 800 feet in length should not be made, as the upper end will become too wet before the lower end is wet enough.
7. If the soil subs readily, water only every other row until late in the season.
8. Do not try to subirrigate with a pump when the sub is falling rapidly or is "lost."
9. Flood the ground before plowing to insure enough moisture to "germinate" the seed.

EARLY POTATO PRODUCTION

The growing of early potatoes in the Western Slope and Greeley districts differs in some respects from general potato growing in this state. Earliness is often of more importance than a large yield. The sandier soils are better adapted to very early crops than are the heavier soils.

Greening the seed and planting the second week in April is much more satisfactory than putting the ungreened seed into cold ground the last week in March. Seed degenerates rapidly, so a seed-plot planted with certified seed should be grown every year.

The planting distances in the early districts should be somewhat closer, as early varieties do not have as large vines and are generally not as heavy yielders as the late varieties. The closer planting will tend to shade the ground better when the vines reach their full size and the weather begins to get warm. Fusarium or wilt is usually a menace in the early districts but can be held in check by careful irrigation.

The early crop should never be allowed to get too wet, and growers often irrigate at night to prevent the "scalding of the plants." It is advisable to irrigate lightly and frequently, using every other row, and the next time over, irrigating in the rows which were skipped during the first irrigation. This will tend to keep soil temperature lower and still avoid the danger of getting the crop too wet.

The Cobbler is the most satisfactory variety for early potatoes, as the Triumph tends to air crack when dug before fully matured and most strains are not as early as Cobblers.

The height of the ridge is best determined by the grower's experience. High ridging will warm the soil more quickly in the spring and force a rapid early growth of the plants, but may cause soil temperatures to become too high during July.

The digger should not be allowed to get too far ahead of the pickers in harvesting because of the danger from sun scald.

NON-IRRIGATED PRODUCTION IN THE NORTHEASTERN DISTRICT

Potatoes are produced without irrigation in many parts of the state. In some of the mountain districts the methods do not differ from methods used in irrigated districts because the annual precipitation is over 20 inches. In areas where the annual precipitation is lower, methods are altered to meet new conditions.

The first point of difference under dryland conditions is in the rotation. Very few soil-building crops are grown and beans are the only crop which is not a heavy feeder. These soils are not inexhaustible and they may hold up for a long time to come, but under present methods they are being depleted. All districts which have grown wheat exclusively have suffered because the native fertility became exhausted. Many of these lands are today worthless. No manure is applied to the land because it loosens the soil and causes it to dry out quicker. Also there is little or none available. Potatoes fit into the dryland rotation very well. Crops produced on land in potatoes the previous year are practically equal to those produced on summer fallow. The quality of the potatoes produced is excellent and there is generally a good local market for them. Freight rates are lower from the plains area than from the mountains. The following rotation is recommended: Wheat, fallow, potatoes or beans; wheat and corn. In sections where summer fallow is impractical because of blowing, potatoes best follow corn.

SOIL PREPARATION.—Plowing is not looked on with much favor by some Colorado growers. The best yields have been obtained on summer fallow. Fall plowing is seldom practiced because of blowing. A shallow plowing early in the spring has given good results when a lister such as the one in Figure 47 is used. This three-row lister has been turned into a potato planter at a cost of $3.00. The

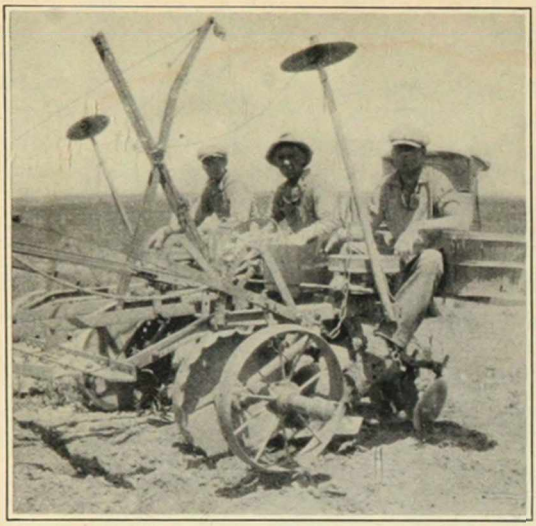

Fig. 47. A three-row lister turned into a potato planter.

mold boards have been removed. The seed-feed wheels are made of old truck brake drums, and the tube thru which the seed falls is made of 4-inch iron casing. This planter places the seed on the hard ground where there is plenty of moisture and practically no danger of drying out. All seed is of course placed in the feed wheel by hand. Corn land should be disced as early as possible in the spring (April). It should be disced again when weeds start and plowed in May for early June planting. Nebraska* experiments showed fall-plowed land produced 13.3 percent more potatoes than spring-disced land. Fallow produced 10.8 percent more potatoes than fall plowing.

SPACING.—Rows are generally 42 to 48 inches apart and the plants 18 to 24 inches apart in the row.

DATE OF PLANTING.—The dryland grower has a serious problem in the best planting date. The Nebraska station has made a thorough study of this subject.† They found after 6 years' study that early plantings (late May and early June) generally produced larger yields, larger tubers, and tubers less likely to air crack in harvesting and which shrunk less in storage; but the tubers were paler colored, more elongated, and contained more scab than later plantings (mid-June to early July). Early blight and fusarium were worse in early plantings, while rhizoc was worse in late plantings. Early plantings produced the best stands. On the strength of these findings the Nebraska station recommends planting between June 15 and 20.

"If common scab is not likely to be serious, the best time is probably about June 5. If severe scab is almost certain to occur, planting after June 20 would be best."

CULTIVATION.—The ground should be kept as level as possible

*Zook, L. L. 1933. Dry Land Crop Production at the North Platte Experiment Substation. Nebr. Sta. Bul. 279.

†Werner, H. O. 1932. Tuber Development in Triumph Potatoes as Influenced by Time of Planting on Dry Land in Northwestern Nebraska. Nebr. Res. Bul. 61.

Fig. 48. Inspecting a dryland certified field. Note the stand, method of cultivation, and row spacing.

to prevent excessive loss of moisture. It is a good practice to cultivate deeply immediately after planting and then harrow to level the ground and prevent excessive evaporation. Future cultivation is for the purpose of controlling weeds, closing cracks which may appear, and keeping the surface in a condition that will readily absorb rainfall.

INSECTS

Altho there are a large number of insects which sometimes

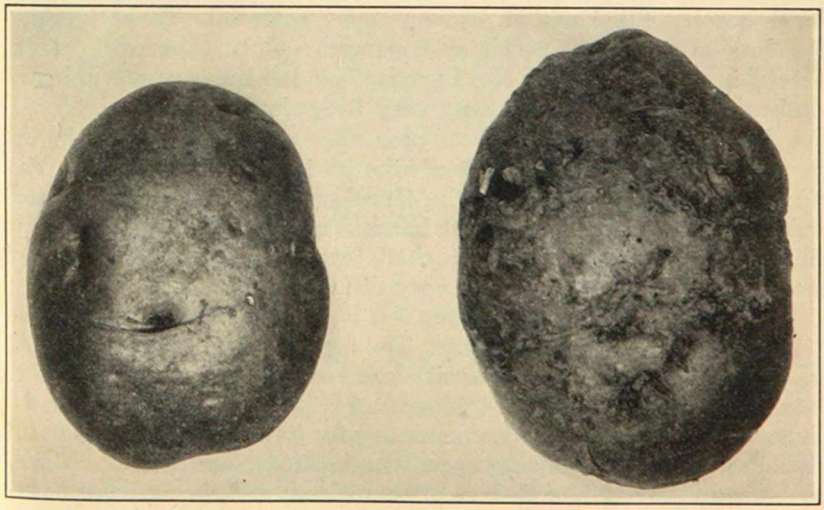

Fig. 49. Potato injured by the potato flea-beetle larvae and an injured potato.

damage the potato crop, there are only four of enough general importance to be considered here. The four insects of general importance and which cause the greatest losses are, the potato "bug," the flea beetle, the potato psyllid and the grasshopper. Until the last 2 or 3 years, growers in Colorado have not sprayed potatoes, except with crude implements for the Colorado potato beetle. Control methods for the flea beetle and the potato psyllid have just recently been worked out by the entomology section of the Colorado Experiment Station. There are no diseases in Colorado of sufficient importance to warrant a spray program, but these insect troubles do warrant such a program.

FLEA BEETLE.—The larva of this insect is the one which causes the "worm track" of potato tubers shown in Figure 49. It is of importance mainly in the Greeley, Montrose and Divide districts at present, but it is also known to occur in several other parts of the state. The adults eat holes in the leaves of many other plants besides potato. These include tomato, pepper, eggplant, nightshade, bean, turnip, radish, cucumber, squash, spinach, lettuce, celery, and a large number of weeds. The insect in its different stages is shown in Figure 50. The injury to the tuber may take two different forms, "worm track" and "pimples." The "worm track" is caused by the larva feeding along the surface of the tuber, leaving small furrows. Scab and rhizoctonia often invade these furrows and increase the disfiguration. Treating the seed materially decreases the invasion of these organisms and lessens the damage. "Pimples" are caused by the larva burrowing straight into the tubers. When a pimple is removed a core or brown "sliver" is found which may extend into the flesh as deeply as 1 inch. These are the burrows of the insects which have become filled with a brown, corky material. These increase the loss in paring as much as 8 percent. Only 5 percent "worm track" is allowed in U. S. No. 1 grade. The damage is worst on heavy moist soils, sandy soils showing very little damage.

Life History.—The insects pass the winter as beetles in the ground. The beetles come out of hibernation the latter part of May and the first part of June in the Greeley district. They start feeding on most any green plant at hand. They then migrate to potato fields. These beetles when disturbed, jump and then feign death for some time, which makes them very difficult to find.

Egg laying begins soon after the beetles emerge from hibernation in late May and early June. The eggs are deposited at a depth of ½ to 2 inches in the moist soil close around the base of the plant. Females average over 100 eggs each. Moisture is necessary for the deposition of eggs and is also necessary for hatching. The eggs hatch in about 10 days, depending upon temperature conditions. At higher temperatures only 7 or 8 days are required; at lower temperatures 12 days are required.

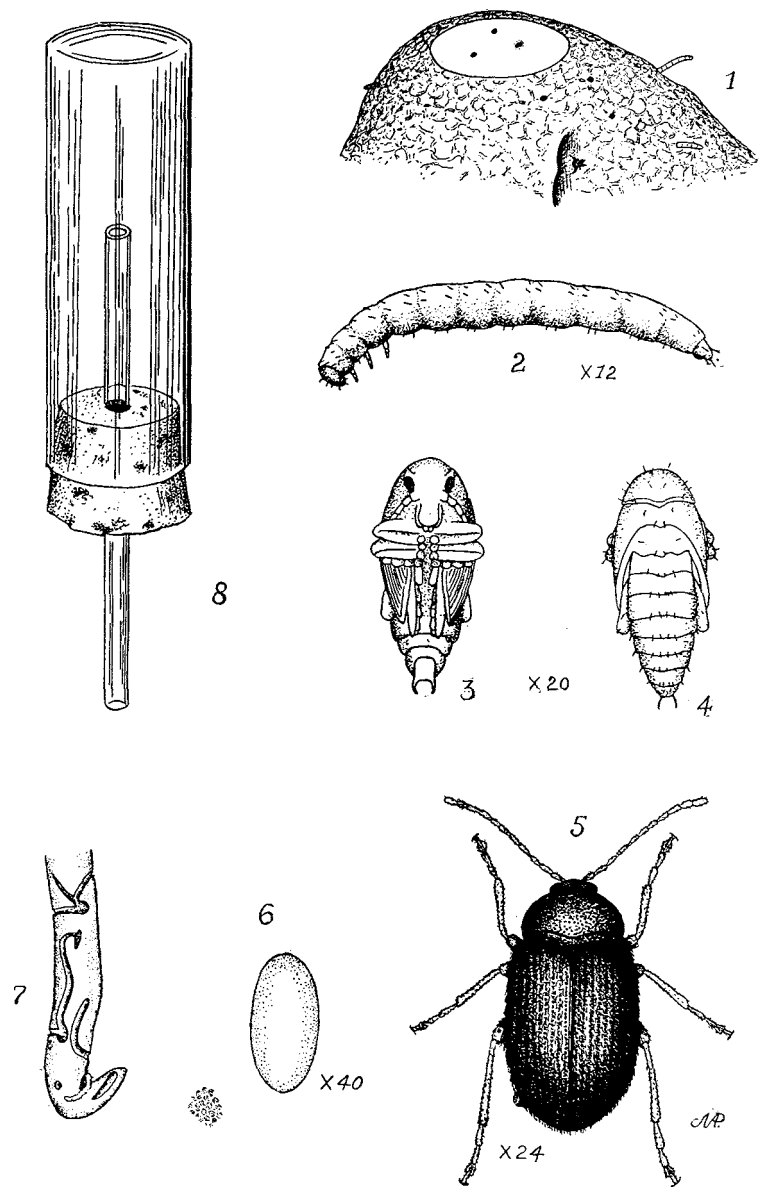

Fig. 50. (1) Portion of potato showing flea-beetle larvae and their punctures; (2) larvae; (3 and 4) front and back views of pupa; (5) adult beetle; and (6) egg; (7) a burrowed potato stem, all much enlarged; (8) collecting bottle with glass tube in the cork, for beetles.

The larvae feed on the roots and tubers for about 26 days. This is also influenced by temperature. The larvae then make small cells in the soil in which to pupate. The average pupal period is about 10

days. Then a new generation of adults emerges. In the Greeley district there is one complete brood and a small part of a second, which is of little or no importance. No parasites have been found associated with this insect.

Control.—The insect can be controlled either by spraying or dusting. Zinc arsenite, 1 pound to 50 gallons of water, has proved to be the best material for spraying. The first application should be made the second or third week in July, depending upon the planting date, in the Greeley district. A power sprayer similar to that shown in Figure 56 should be used. A pressure of at least 250 pounds per square inch should be maintained. These applications should be made at 10-day or 2-week intervals.

Dusting, calcium arsenate—1 pound to 8 pounds of hydrated lime—gives very efficient control. Two or three applications are necessary and are applied at the same time as recommended for the sprays. They should be applied with a duster at the rate of 20 to 30 pounds to the acre, depending upon the size of the plants. The cost of materials for dusting is about 75 cents per acre. The most satisfactory time for dusting is in the early morning or late afternoon. A more complete discussion of flea beetles and flea-beetle control may be found in Colorado Station Bulletin 337, "The Potato Flea Beetle," by Hoerner and Gillette, and Bulletin 400, "Potato Flea-Beetle Control," by L. B. Daniels.

PSYLLID YELLOWS.—The potato psyllid was first associated with a trouble previously known in Colorado as "blight" and "purple top," by Richards* of Utah in 1927. The insect and disease were first identified in Colorado at Fruita in 1928, but have since been found in practically all parts of the state. It is highly probable that the disease has been in the state since 1876, but its cause remained unknown until Richards associated the psyllid with it. There is little doubt that the disease epidemic of 1911 to 1914 was caused by this trouble. There is no potato disease or trouble which spreads as rapidly and uniformly or causes the enormous losses that psyllid yellows does. So far it has been reported from all states west of Nebraska.

Symptoms.—The first symptoms of psyllid yellows consist of an upward rolling or cupping of the basal portion of the leaflets, toward the top of the plant (Figure 51). This rolling is generally accompanied by a marginal yellowing. In Bliss Triumph and Irish Cobbler the upper parts of the plant may assume a distinct reddish or purplish color. In Brown Beauty, Russet Burbank and Peachblow this purplish color often fails to appear, but yellowing is always evident. The symptoms spread from the top downward, in severe cases involving the entire plant. The first symptoms generally seem to appear, in Colorado, about the time the plants come into bloom.

*Richards, B. L. Psyllid Yellows of the Potato. Utah Station Reprint 225.

The nodes of the plants enlarge and the axillary buds are stimulated into growth, producing either an aerial tuber or a stocky shoot capped with a rosette of leaves, which when fully developed gives the plant a compact pyramidal shape. (Figure 53.) The axillary growths force the main stem to one side, giving it a zigzag appearance, thus making it appear that the plant shrinks in size. These plants in Colorado generally set an extremely large number of tubers, 50 on Irish Cobbler being quite common. These tubers seldom attain marketable size and often sprout in the soil before digging time. In other cases they sprout soon after being put in storage.

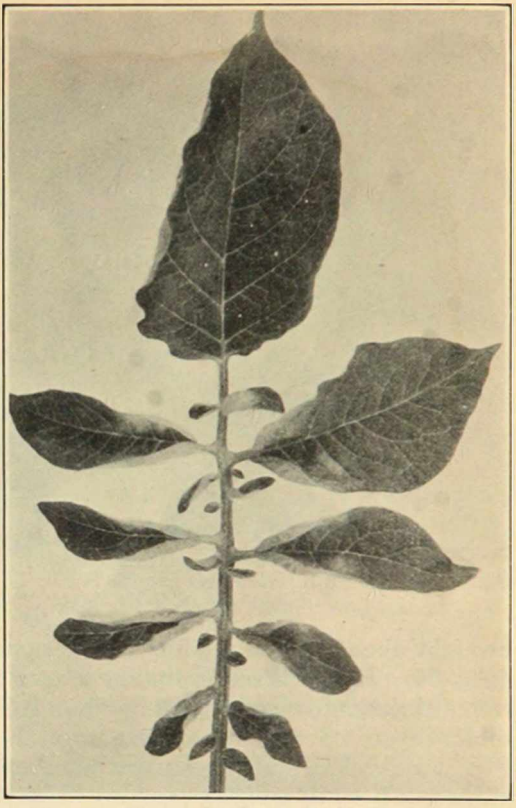

Fig. 51. First symptoms of psyllid yellows. (Courtesy of Utah Experiment Station.)

Considerable investigation has been carried on at the Colorado Experiment Station to determine the value of tubers from infected plants for seed. Greenhouse studies over a period of 6 years have shown that the symptoms observed in the field are apparently not perpetuated by the seed. One year's field test seems to indicate that the yield is not significantly affected by the condition. Fields have been observed during the past 6 years which were planted with seed from fields infected the previous season. In no case were the conditions observed in the absence of the insect, and yields did not seem to be affected. Light seems to have considerable influence on the appearance of the symptoms and severity of the damage. An infected field was observed which had a heavy stand of volunteer oats in one corner. Few nymphs and no symptoms were present here and a good yield was secured, while the rest of the field was almost a failure. Rain seems to slow the progress of infection.

Cause.—The condition above described is in some manner

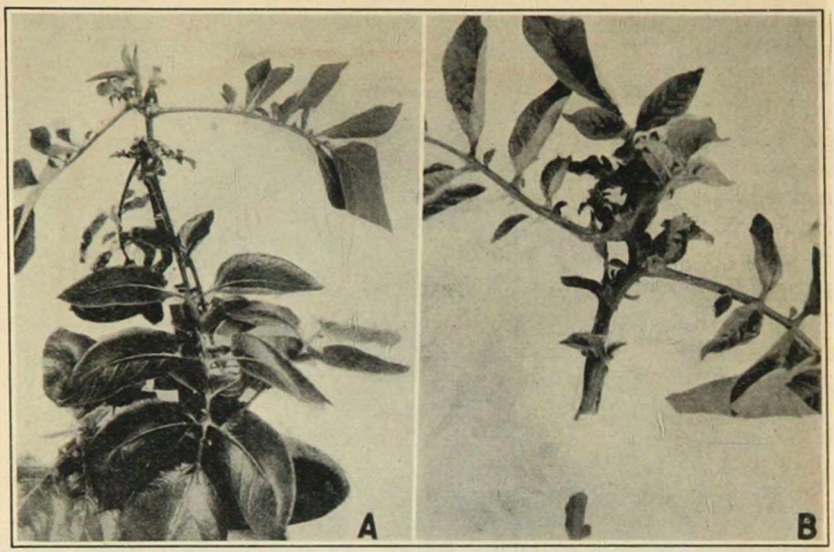

Fig. 52. The peculiar terminal growth which is a symptom of psyllid yellows. (Courtesy of Utah Experiment Station.)

brought about by the feeding of the nymphs of the tomato psyllid (Fig. 54). Richards found that as few as 3 to 5 nymphs might occasionally produce psyllid yellows but full expression of symptoms seldom resulted with fewer than 15 to 30 actively feeding nymphs. Five hundred nymphs per plant have often been observed by the author. These nymphs must feed for a period of at least 16 days. If the insects are removed in less time the plant shows a tendency to recover. The adults up to 1,000 per plant appear incapable of pro-

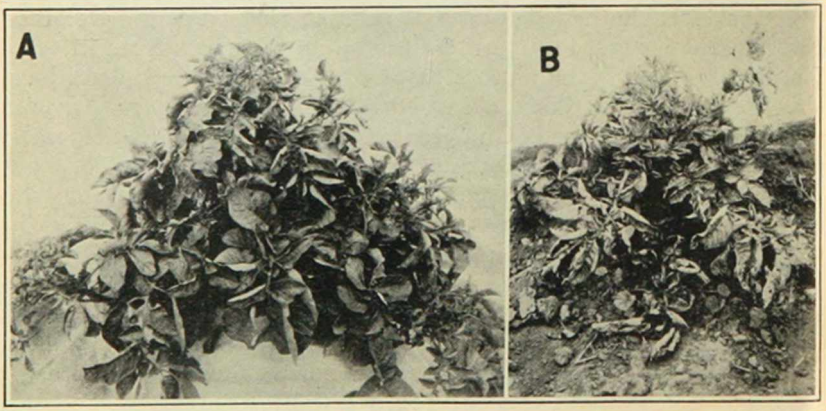

Fig. 53. (A) Irish Cobbler severely damaged by psyllid yellows. (B) Irish Cobbler very severely damaged by psyllid yellows. (Courtesy of Utah Experiment Station.)

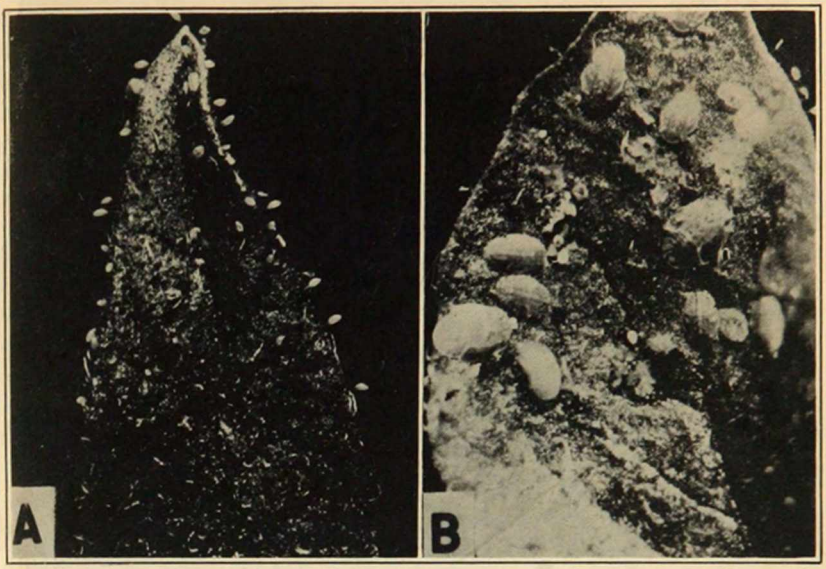

Fig. 54. (A) Eggs of the tomato psyllid. (B) Nymphs feeding on a potato leaf. (Courtesy of Utah Experiment Station.)

ducing psyllid yellows. All attempts at transmitting the disease, other than by the feeding of nymphs of the psyllid have met with

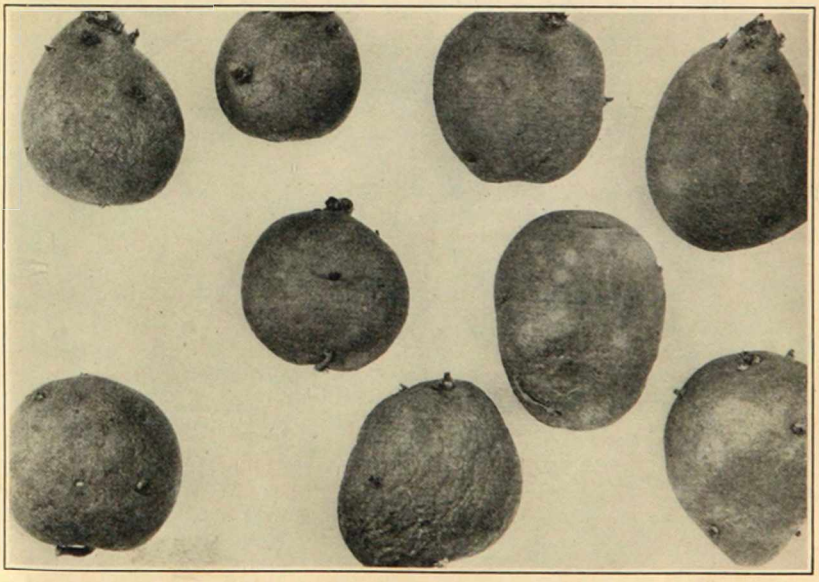

Fig. 55. Brown Beauty tubers from a field severely damaged by psyllids. Premature sprouting is characteristic.

failure. Full expression of symptoms results only when nymphs are allowed to feed continuously on the infected plant. When Richards removed nymphs which had been feeding 26 days the progress of the disease stopped abruptly. From this fact it would appear that some control might be obtained by killing the insects even after 26 days. Symptoms do not appear until after the nymphs have been feeding for 3 days and full expressions of symptoms are not obtained until nymphs have been feeding continuously for 36 days. Symptoms of the disease have never been observed in Colorado in the absence of nymphs. The adult is a very small, fly-like insect which is very active and is known as the "jumping plant louse." It can only be observed late in the fall during cool weather. At other times it is too active to capture. It can be readily identified on infected plants by a white "Y" on the black back of the insect. The open end of the "Y" is toward the rear end of the insect. The average life of females is about 35 days. The female begins laying eggs about 10 days after it emerges. The insects lay eggs for an average of about 35 days, and average about 720 eggs each. The nymphs require an average of 16 days for their development. The skins are shed and the adult emerges. These skin casts can often be found on the leaves of the infected plants. The small nymphs when first hatched are brown in color, but turn green as they approach maturity.

Control.—A number of parasites have been observed on this insect. It is also known that the "lady-bug" feeds on this insect

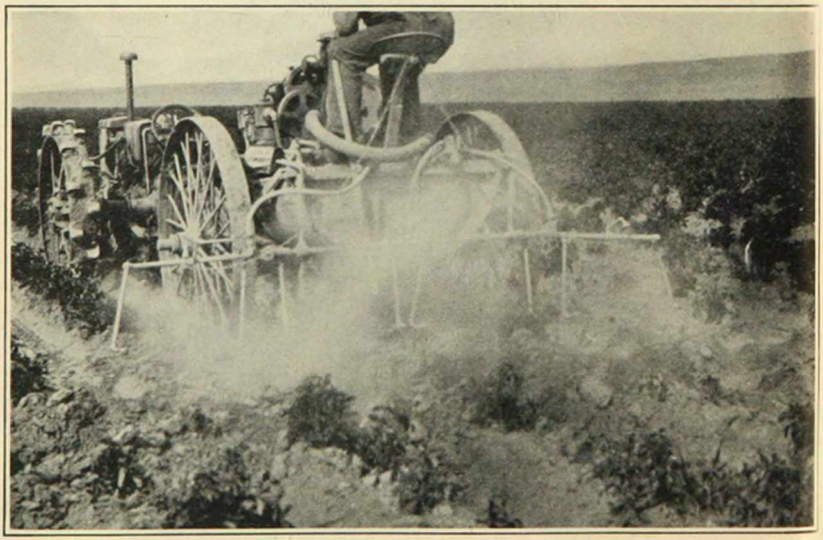

Fig. 56. A four-row power sprayer which will develop at least 250 pound pressure is necessary to control psyllid yellows.

but it is hardly possible that much control can be expected from this source because of the rapidity with which the psyllid increases. In 1933, the entomology section of the Colorado Experiment Station recommended lime-sulphur as a control. One gallon of lime-sulphur is mixed with 40 gallons of water. A high-pressure sprayer is necessary to apply this mixture; 250 pounds pressure should be maintained and there should be 3 nozzles to each row. All the details of control have not yet been worked out and it seems probable that at least two applications should be made for satisfactory control. The spraying should be done as soon as possible after first symptoms appear. Enormous increases in yields have been obtained in experimental plots and the work is being continued. For more detailed information consult Station Bulletins 410 and 411.

Potato "Bugs".—Growers in different districts know different insects as potato "bugs." The Colorado potato beetle has black stripes on a pale yellow ground. It is rather large, about a half-inch in diameter. The larvae are reddish colored. Both the larvae and adults are heavy feeders and will strip a vine of its leaves in a few days. This insect occurs mainly in the Greeley and northeastern districts. A black, slim blister beetle over a half-inch long is also known as a potato "bug." There is also a gray blister beetle very similar to the black one which also feeds on potatoes. These insects can be controlled by spraying with stomach poisons. Paris green has been commonly used in the past, but is more expensive than other materials and sometimes burns the foliage. Arsenate of lead gives satisfactory control and also the materials recommended for the flea beetle. Lime-sulphur and zinc arsenite may be combined in one spray for the control of flea beetles, psyllid yellows and potato "bugs," in which case 2 pounds of hydrated lime and 2 pounds of zinc arsenite should be added for each gallon of lime-sulphur.

GRASSHOPPERS.—Growers sometimes experience a great amount of damage from grasshoppers, especially in Eastern Colorado. These insects are controlled thru the use of poisoned-bran mash. Grasshoppers feed very early in the morning. The fresh bran mash should be scattered thinly over the field about 4 a. m. each morning. The mash should not be left in piles but should be broadcast thinly thru the field. Make sure that the mash is mixed properly and is not too wet. If it is too wet it will fall in chunks and not break up when a handful is thrown. The following formula for poisoned-bran mash is recommended:

Paris green or crude white arsenic	1 pound
Wheat bran	25 pounds
Cheap molasses	2 quarts
Water	10 quarts
Lemons or oranges	3

Grind the fruit and mix with the molasses, poison and water. Agitate thoroly. Pour onto the bran and mix thoroly. The mixing can be done in a tub or tight box. Ten to 20 pounds per acre are required.

HARVESTING

Many excellent crops of potatoes are ruined by careless or inefficient harvesting and handling methods. This damage may consist of digger cuts, cracks, bruises or skinning, sometimes also known as feathering. These injuries not only increase the percentage of culls but also detract from the appearance of the potato. There is more loss in preparing them for table, more shrink and these injuries provide an avenue for the entrance of rot organisms which cannot penetrate the sound skin of a tuber.

Mechanical injuries vary considerably, ranging from 5 to 95 percent. Certain varieties are more susceptible to damage than others.

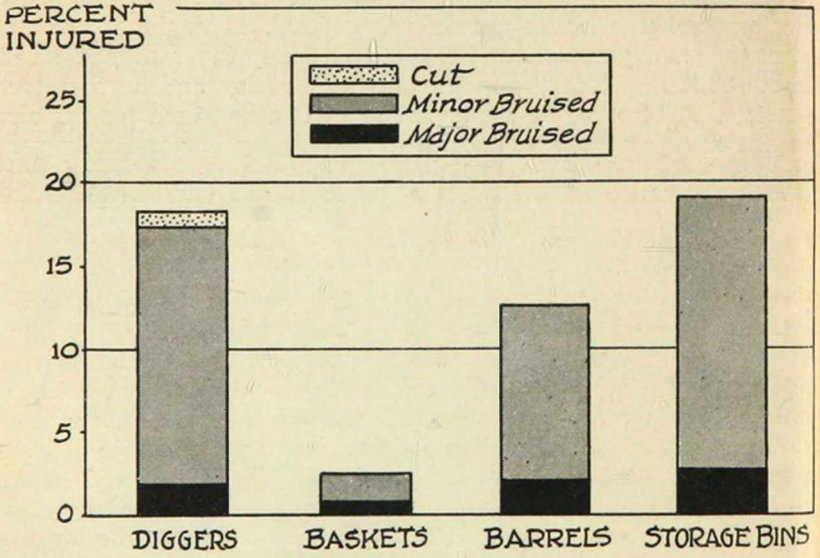

Fig. 57. Injuries caused by different harvesting operations in Maine.

Werner* in Nebraska found that four times as many Triumph tubers air cracked in harvesting as Irish Cobblers and that the cracks in the Triumphs were nine times longer than in the Cobblers. He also found that 1.74 percent of the Cobblers were cut in digging and that these cuts tended to heal in storage; that cuts in the Triumphs averaged 4.28 percent and that these cut tubers tended to rot in storage. These injuries cannot be altogether eliminated, but can be greatly reduced if the crop is properly dug and handled.

*Werner, H. O. 1931. The Cause and Prevention of Mechanical Injuries to Potatoes, Nebraska Station Bulletin 260.

The Nebraska Station in a 3-year study found that an average of 31.1 percent of all tubers harvested in 1928 were cut and air cracked. In 1929 the percentage was 16.0 percent and 1930, was 16.6 percent.

The Maine Experiment Station† found that an average of 47.81 percent of the tubers harvested in that state were mechanically in-

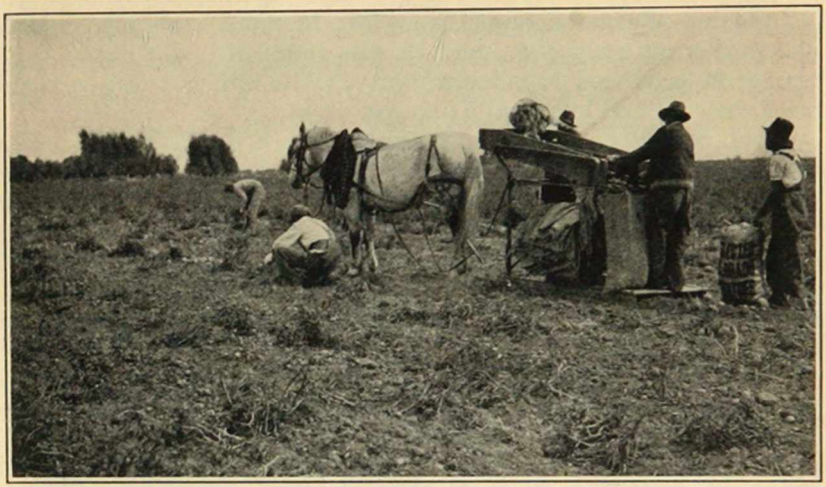

Fig. 58. Sorting in the field. The picker holds the basket close to the screen and the sorter is not shaken.

jured. Of this total 7.1 percent were major injuries, that is, severe enough to be grade defects and throw them out of U. S. No. 1 grade. These major injuries increased to 9.65 percent after 2 months' storage. In addition to the major injuries there were 40.71 percent of minor injuries, not serious enough to affect the grade but still serious enough to damage the appearance and quality of the crop. A survey showed that mechanical injury was the most common and serious defect found in Maine potatoes. Two percent of bruising lowered prices in Boston markets and "15 percent of bruising lowered prices nearly one-third during the 1929-1930 season." A condition as serious as this surely deserves considerable attention by potato growers.

Conditions as bad as these or worse exist here in Colorado.

More attention should be given to the maturity of the crop, the soil condition at digging time, protection from digger injuries, more careful picking and more attention to containers, careful handling from the field to the storage, more careful handling in placing in the bins, more attention to preventing injury in grading and in loading cars.

†Schrumpf, Wm. E. 1933. The Effect of Handling Methods on Qualities of Maine Potatoes, Maine Station Bulletin, 365.

A crop which is fully matured is much less liable to injury than one which is immature at digging time. This maturity can best be obtained by planting early enough or selecting an earlier maturing variety or strain. The growers should cease irrigating at least 3 weeks before the crop is to be harvested as this will promote the maturing of the crop and lessen the damage in digging. Digging should also be delayed as long as possible and still escape the danger of freezing. Werner obtained from 6 to 15 times more injury from late than from early plantings. He also found that digging on September 29 produced 24 percent injury, while 8 days later, on October 7, he obtained less than 5 percent.

Soil conditions at digging time also have a decided influence on mechanical injury. When soils are too dry, clods may go over the digger with the tubers and cause considerable injury. The soil is also sifted thru the elevator more readily and tubers bouncing around on the unprotected rods are injured more than those carried over with some soil. The rods are also protected to some extent by a layer of soil when the soil is damp. Stones also increase the amount of damage.

In Maine it was found that where less than 149 stones per 100 pounds of potatoes passed over the digger the injury was 9.34 percent; where more than 450 stones passed over with 100 pounds of potatoes the number of tubers injured was 24.26 percent. Clods will also have a similar effect. In Nebraska it was found that larger tubers were injured twice as much as smaller ones. Deep planting also produces more injury than shallow planting.

DIGGERS.—Diggers are the cause of a very large percentage of mechanical injury. It is unfortunate that no changes or improvements have been made in diggers for the past 30 years, and there is no digger which comes from the manufacturers today which cannot be improved upon by the grower and the amount of injury materially reduced.

Two types of injury are caused by diggers: Cuts and bruises. In Maine it was found that 18.31 percent of the tubers were injured by the digger, .93 percent cuts, 17.38 percent bruises, of which 1.75 percent were major. The amount of injury depends to a considerable extent on the type of digger and on the power used. In Maine it was found that horse-drawn diggers cut 1.34 percent of the tubers, engine diggers, .84 percent and power take-off tractor diggers, .57 percent. Traction diggers with shakers at the rear end bruised 28.15 percent of the tubers, while horse-drawn diggers carrying a gasoline engine to operate the elevator bruised 20.47 percent of the tubers. Engine operated continuous elevator diggers bruised 12.75 percent, while power take-off continuous elevators bruised 11.73 percent.

In Nebraska it was found that power take-off diggers injured 16.2 percent of the tubers and horse-drawn machines injured 24.8 percent.

In addition to the power used, certain other points should be taken into consideration in the digger and its operation. Diggers 26 inches wide are recommended for all late varieties and also for Bliss Triumphs. Narrower diggers may be used for Irish Cobblers. The digger should be low wheeled so that the elevator will not be too steep and cause the potatoes to roll continuously down. Low wheels also make it possible to dig both ways on ground which has a little slope. There should not be two aprons on the machine, as considerable bruising is caused by the drop from the elevator to the rear apron.

The digger should be re-designed so that there is one continuous chain going clear to the rear end. It will be necessary to build up the teeth on the drive sprocket by welding and also to provide supports for the chains under the digger to keep the chain from dragging the ground. The tail of the digger should be adjustable and be run as close to the ground as possible. In some soils the agitators should be replaced by rollers. All places on the diggers which are struck by potatoes should be padded with old inner tubes, tires, rubber hose or old sacks. In addition it may be advisable to put discs in front of the digger blade so that they will force soil onto the digger point. If these discs are kept sharp they may also serve to cut off large vines which often cause considerable trouble as well as bruising the tubers.

PICKING.—The amount of damage caused by picking up and subsequent operations may be materially reduced by allowing the tubers to lie on the ground for 1 to 4 hours. This allows the tubers to dry, the skin to toughen, and reduces the amount of dirt carried into the cellars. In Maine it was found that 2.22 percent of the tubers were damaged by splint baskets. In Nebraska 45 percent of the tubers were cracked by tossing them into unlined baskets, while 25 percent were cracked when baskets were lined with one or

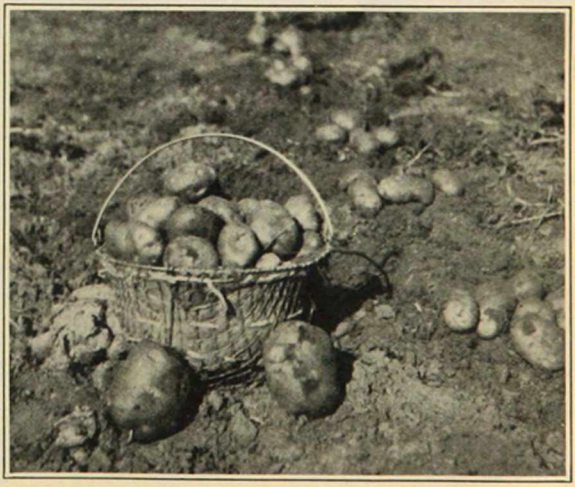

Fig. 59. Padding the basket prevents bruises.

two layers of burlap. When tubers were allowed to dry for 25 minutes only 12.5 percent were cracked by placing in lined wire baskets. Tubers are not only injured by the baskets themselves but are also injured by falling on other tubers. Dropping only 12 inches cracked 59.5 percent and the cracks were more severe than when the tubers simply hit the basket. A delay of 40 minutes in picking reduced the percentage cracked to 13.3 percent.

The next operation, emptying the potatoes from the basket into a sack or barrel, causes more damage than picking up. In Nebraska 3 to 60 percent of the tubers were damaged when emptied into sacks. In Maine, 8.16 percent were damaged by emptying into barrels. In Nebraska, 19.7 percent were cracked when dropped 30 inches but none were cracked when dropped only 12 inches. After drying 30 minutes a 12-inch drop produced little damage and a drop of 30 inches cracked only 4.9 percent.

These facts lead to the following recommendations for preventing injuries in picking up: The tubers should be dug from 1 to 3 hours before picking; a longer time is desirable where possible. Extreme care and considerable judgment are required here, however, as bright sunshine and high temperatures produce sun scald. There is particular danger from sun scald in the San Luis Valley and also in early districts. Baskets should be lined with one or two layers of burlap.

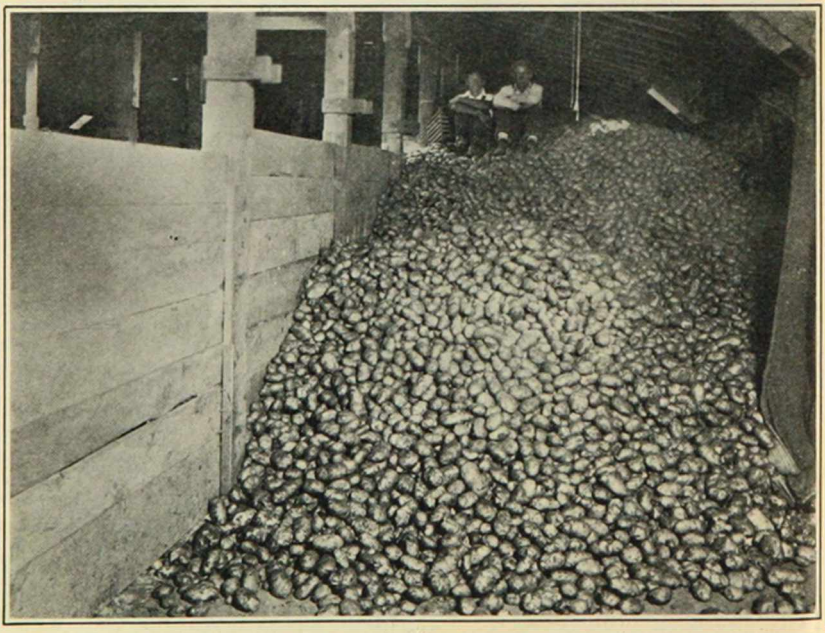

Fig. 60. Who would care to buy these potatoes?

Screening in the field is also a serious source of damage and in many districts of the state is not practiced for this reason. No figures are available on the damage caused by grading in the field. The pickers should not be allowed to dump potatoes into sacks from an upright position, but should carefully roll them into the sack, especially when putting in the second basketful.

HANDLING FROM FIELD TO STORAGE.—Hauling from the field and dumping into bins produced more injury in Maine than any other operation. A total of 19.12 percent of the tubers was damaged, of which 2.65 percent was major injury and 16.4 percent was minor injury.

The practice of spouting the tubers thru the roof into the bins, which is also done in some parts of Colorado, produced more injury than driving into the cellar and emptying into the bins.

The following recommendations will reduce injury in getting potatoes from the field into the storage bin: The less the sacks are handled the less injury there will be. The "buckers" should grasp the half sacks close to the potatoes in order to keep them from rolling around. The potatoes should not be dropped or thrown into the wagon or truck. It is a good idea to line the wagon or truck with straw. A low-wheeled wagon is best for moving the potatoes from the field. The "buckers" should not be allowed to walk over the potatoes either in the sacks, on the wagon or truck, or when emptying them into the bin. The best method of filling bins is to dump the potatoes carefully, starting at the rear end and putting in a layer about a foot deep. A plank is then put across the bin not more than 2 feet above the surface of the potatoes and another layer a foot deep is put in and so on until the bin is full. The old practice of "tailing" the potatoes out of the sacks with a throwing motion should not be tolerated.

FULL SACKS.—Full sacks in the field are most generally associated with sorting in the field. This method may be used where the potatoes are very well matured or where they are to be shipped directly from the field. The sorter should be well padded at all the places where the potatoes strike. The sorter should not be shaken when pickers are emptying baskets onto the screen. Pickers should be instructed to empty the baskets carefully. Pads should be placed under the sacks on the sorter to prevent bruising the first tubers which drop into the sack. The sacks should be well filled and tightly sewed. Many growers claim that they can afford to lose all of their sacks from deterioration in storage and still be money ahead because of the smaller amount of damage incurred by this method. These sacks should not be used for marketing the crop.

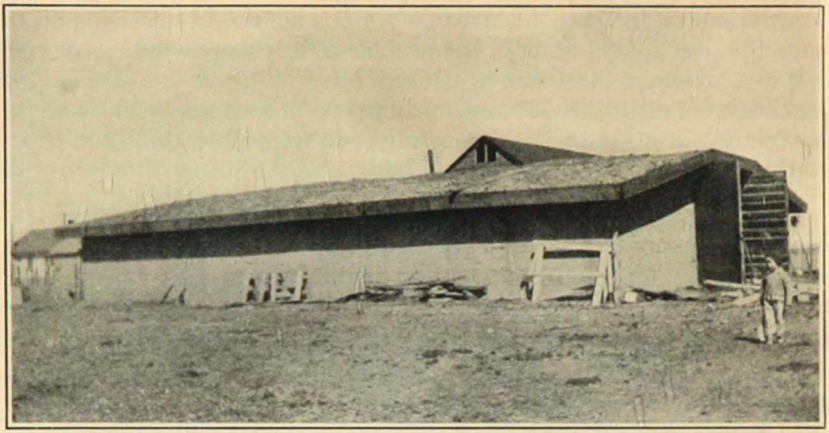

Fig. 61. The adobe-type house used in the San Luis Valley. Dug cellars cannot be used because of the high water table.

STORAGE

The object of potato storage is to keep the tubers from freezing and in a dormant condition with as little loss from rots and shrinkage as possible until they can be marketed. Growers most commonly store in anticipation of higher prices later in the season. Storage also makes possible the more uniform movement of the crop to market thruout the winter. It is not always a profitable practice for the

Table 22. Comparative prices by crop years.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
1910	*$0.80*	**$0.70**	$0.60	$0.53	$0.54	$0.60	$0.60	$0.70	$0.77	*$1.22*	*$1.70*	*$1.62*
1911	*1.35*	.98	.90	.94	.90	.95	1.02	1.20	**1.46**	*1.40*	*1.15*	*.94*
1912	*.70*	**.55**	.46	.38	.35	.39	.42	.36	.30	.34	.49	*.69*
1913	*.70*	**.62**	.63	.62	.60	.60	.60	.58	.58	*.74*	*.86*	*.88*
1914	*.81*	**.72**	.62	.48	.50	.58	.57	.63	.71	*.73*	*.86*	*.82*
1915	*.54*	.42	.48	.58	.70	.76	.80	.95	**1.05**	*1.18*	*1.33*	*1.30*
1916	*1.00*	1.03	1.30	1.30	1.38	1.94	2.20	2.28	**2.58**	*2.57*	*2.44*	*1.86*
1917	*1.13*	.88	.90	.94	**1.06**	1.04	.85	.64	.51	*.51*	*1.20*	*1.68*
1918	*1.32*	**.97**	.88	.88	.76	.70	.66	.77	.83	*.76*	*1.20*	*1.60*
1919	*1.55*	1.50	1.58	1.62	1.81	2.26	2.74	3.30	**4.28**	*4.50*	*4.00*	*2.65*
1920	*1.23*	**.94**	.76	.70	.60	.56	.64	.68	.67	*.81*	*.96*	*1.10*
1921	*1.03*	**.90**	.81	.66	.77	.80	.70	.64	.55	*.62*	*.70*	*.88*
1922	*.76*	**.48**	.41	.32	.41	.40	.34	.45	.43	*.41*	*.96*	*1.28*
1923	*.95*	**.74**	.65	.64	.71	.65	.65	.70	.71	*1.80*	*1.50*	*1.20*
1924	*.60*	.53	.51	.52	.63	.64	.80	.77	**.85**	*1.13*	*1.66*	*1.52*
1925	*1.14*	1.10	1.88	1.73	1.93	1.78	1.75	**2.30**	1.80	*1.45*	*1.40*	*1.05*
1926	*1.10*	1.15	**1.30**	1.25	1.30	1.10	1.10	1.15	1.35	*1.70*	*2.00*	*1.40*
1927	*.85*	.65	.60	.60	.55	.55	**.80**	.80	.60	*.55*	*.75*	*.65*
1928	*.55*	.35	**.45**	.45	.45	.40	.45	.45	.45	*.50*	*1.00*	*1.20*
1929	*1.15*	1.10	1.15	1.15	1.10	1.15	1.20	1.20	**1.40**	*1.50*	*1.15*	*1.05*
1930	*.85*	**.70**	.70	.60	.60	.55	.50	.60	.55	*.50*	*.75*	*.70*
1931	*.35*	**.30**	.30	.30	.29	.26	.27	..	..	..	..	..

Colorado Yearbook, 1932.
Figures in italics are prices for the early crop.
Figures in bold face type are the highest for the late crop.

grower, however. A study of Table 22 shows that in 13 of the 22 seasons the highest prices received by growers were in October and November. In two seasons the highest prices for the late crop occurred in January and March. In the other seven seasons the highest prices were obtained after April 1. In five of these seven seasons the total United States crop was very much below normal.

This cannot be used as an argument for selling from the field as it is impossible to dispose of the entire national crop at that time. In seasons of large crops the very fact that so much was moved at digging time had a depressing effect on the market during practically the entire winter. This depressing effect was overcome only twice in 22 years, 1917 and 1927. In 1916, 1919 and 1925 enormous profits were made by storage. The most satisfactory plan is to market part of it at intervals thru the season. The plan of constantly holding for higher prices is almost as unsatisfactory as "dumping" the entire crop on the market at digging time. In 1925 and in 1933 too many growers held too long. A short crop became a long one because supplies at the end of the season exceeded possible consumption and prices dropped sharply toward spring.

The most common types of storage cellars are illustrated in Figures 61 and 62. The interior arrangement, however, should be practically the same in all types. The most important factor in the interior arrangement is the circulation of air *within* the cellar. False floors should be provided for the bins; 2x4's on edge at right angles to the driveway, with 1x4's one inch apart forming the floor will provide adequate air space under the bins. These should be built in sections small enough to handle as they must be removed occasionally so that dirt and trash may be removed from under

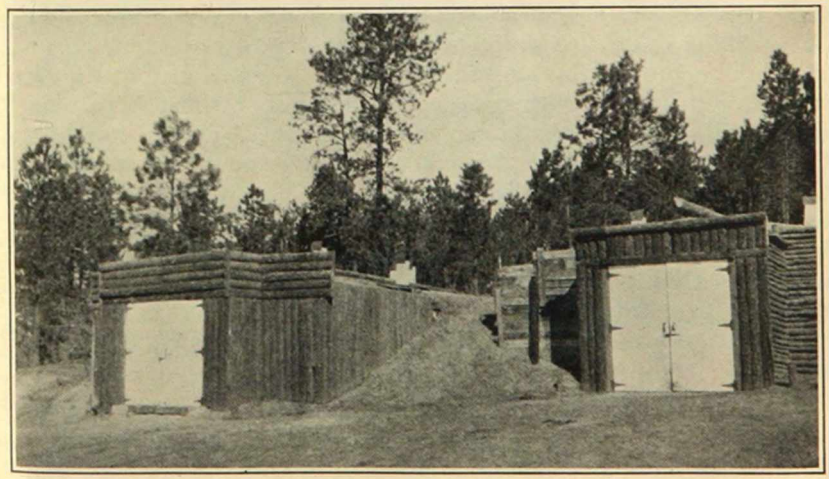

Fig. 62. The single-entrance bank type.

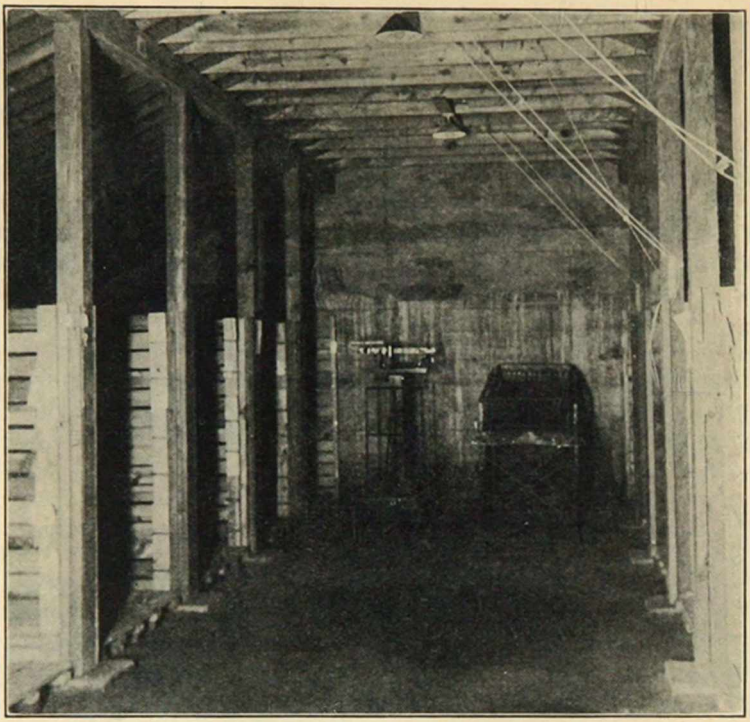

Fig. 63. Storage cellar—showing slatted floor raised 4 inches above ground floor. Bins are divided by double slatted walls.

them. A false back wall made of the same materials should also be provided. This insures air circulation around the entire pile of potatoes. For bulk storage, double slatted partitions between bins should be provided or square slatted ventilators placed at 6-foot intervals along the center of the bin. The closing of the entrance to the bins is most easily accomplished by boards resting on short 2x4's nailed to the posts and placed at an angle of 45 degrees. These boards may be put in place as the bin is filled or may be removed independently when emptying the bin. The contents of a bin may be determined by dividing the number of cubic feet of potatoes by 1.224, the number of cubic feet required for a bushel. In the case of sack storage, no bin partitions or bin fronts are necessary. Many growers claim that less loss and damage results from sack storage and that they can afford to lose all the sacks in which the potatoes are stored and still be money ahead.

TEMPERATURES.—All potato cellars should be provided with two or three thermometers which should be read often, especially at times when there are wide fluctuations in weather conditions. Potatoes freeze at 26 or 28 degrees F. but should never be allowed to

get below 30 degrees for safety. After the first 2 months, temperatures above 40 degrees will cause sprouting. The temperature then should be kept between 30 and 40 degrees, with 35 as the ideal. Tubers kept at around 32 degrees for a period of time have a sweet taste when cooked but lose it when stored at 70 to 75 degrees F. for a week. Disease organisms do not work as rapidly at the lower temperatures. All lots of potatoes have more or less mechanical injury as a result of harvesting and placing in the cellar. These injuries will heal or cork over in about 2 weeks if the temperature is left between 50 and 60 degrees and moisture is present. No attempt should be made to bring the temperature below 40 degrees until 2 weeks after the crop has been put in storage. Potatoes have a dormant period of about 2 months unless injured by psyllids, so there is no danger of sprouting at this time.

HUMIDITY.—Dry cellars cause excessive loss of moisture from the tubers. A relative humidity of 90 percent is desirable. A high relative humidity is necessary for the healing of wounds when the potatoes are first put in storage. Growers in Nebraska have found it desirable to wet down the bins and driveway before the potatoes are stored. The driveway is also wet down at intervals during the winter whenever it gets dry. This practice maintains a satisfactory humidity and prevents excessive shrinkage. Potatoes go thru a "sweat" when first placed in storage and lose some moisture then. If the proper humidity and temperature are maintained this should be practically all the moisture loss until April, May, or even June, depending on the locality.

Fig. 64. Storing in sacks is a good method, but these are not properly piled.

VENTILATION.—The importance of ventilation with fresh air for stored potatoes has undoubtedly been greatly over-emphasized. Many intricate ventilation systems have been devised to keep a constant stream of outside air flowing thru the cellar. The only object in introducing outside air is to regulate the temperature. Too much outside air simply increases the shrinkage. Plenty of opportunity for the air *enclosed in the cellar* to circulate should be provided as described above.

SHRINKAGE.—Under good storage conditions the loss from evaporation of water should not be much in excess of 2 percent. Records on losses in storage have been investigated for 2 years at the Mountain Substation. The Russet Burbank and Peachblow varieties were used. The tubers were sorted to U. S. No. 1 grade and stored in sacks even weighted to 100 pounds each. They were resorted and weighed May 15 with the following results:

		Lbs.	Percent
Russet Burbank			
1931 Crop			
Total shrinkage	(4 lots, 2,000 lbs.)	50.5 or	2.5
Total rots	(4 lots, 2,000 lbs.)	93.5 or	4.7
Total loss	(4 lots, 2,000 lbs.)	144.0 or	7.2
1932 Crop			
Total shrinkage	(4 lots, 2,000 lbs.)	9.4 or	4.7
Total rots	(4 lots, 2,000 lbs.)	68.0 or	3.4
Total loss	(4 lots, 2,000 lbs.)	162.0 or	8.1
Peachblow			
1931 Crop			
Total shrinkage	(4 lots, 2,000 lbs.)	89.5 or	4.5
Total rots	(4 lots, 2,000 lbs.)	215.0 or	10.7
Total loss	(4 lots, 2,000 lbs.)	304.5 or	15.2
1932 Crop			
Total shrinkage	(4 lots, 2,000 lbs.)	97.5 or	4.875
Total rots	(4 lots, 2,000 lbs.)	127.0 or	6.35
Total loss	(4 lots, 2,000 lbs.)	224.5 or	11.225

Monthly weighings showed that practically all the weight loss took place in the first 2 months and the last month of the storage period.

LIGHT.—The storage house should always be kept dark, as light causes the tubers to green and impairs their eating quality, but does not injure them for seed. Many growers allow the doors on the cellar to remain open for long periods in the fall in order to get the temperature down. Severe "light burn" or greening is always the result.

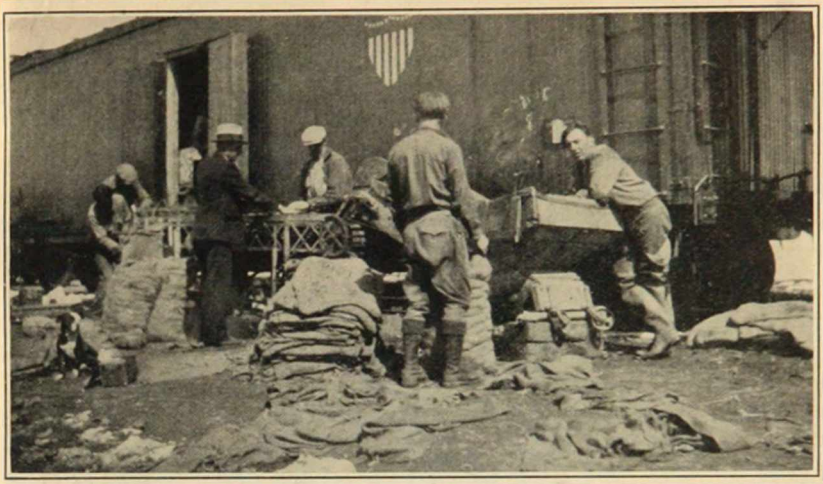

Fig. 65. The penalty for improper grading. Regrading a car before shipment.

FUMIGATION.—In cases where good seed is used and there is no field frost, growers in Colorado have little trouble with wet rots but dry rot is always a problem. This trouble is caused by one of the fusariums which cannot enter the skin of a sound tuber but enters thru a cut or bruise. More care in harvesting greatly assists in controlling this disease. Healing the wounds at the first of the storage period as described above is also a great aid. Temperatures between 32 and 36 degrees F. prevent the rapid growth of the organism. The disease is spread by seeds or spores which are very fine dust-like particles almost invisible to the naked eye. These live over from season to season in the storage house and in old sacks. Cellars should be fumigated every year to kill these spores. The following formula is recommended:

> Use 11 ounces of formaldehyde (40 percent), 11 ounces of potassium permanganate crystals and 9 ounces of water per 1,000 square feet of space. Place the formaldehyde and water in a large receptacle in the cellar, add the potassium permanganate and *leave immediately*. Close the cellar tightly and leave closed for several days or a week. For a cellar 75x40x10 feet, 30 batches of this material are required. The containers should all be placed and the water and formaldehyde added to each, then close one end of the cellar tightly and add the potassium permanganate to each as quickly as possible, going toward the open door at the other end. *Leave immediately* and close doors tightly.

MARKETING

Potato growers must remember that good appearance in potatoes is more important to the purchaser than good cooking quality. This demand for bright-skinned, well-sized, clean tubers free from defects caused by diseases, insects or handling, has led to a number of new practices. Packages have become smaller, uniform-sized potatoes are placed in them, and some states now wash or brush the tubers to remove all dirt.

GRADING

The term "grading" covers a "multitude of sins" and consists of anything from running the tubers over a screen to remove the small ones to hand picking for special packs. Colorado has compulsory inspection on potatoes and as a result all potatoes are sold on the basis of the U. S. grades, which now consist of U. S. No. 1, U. S.

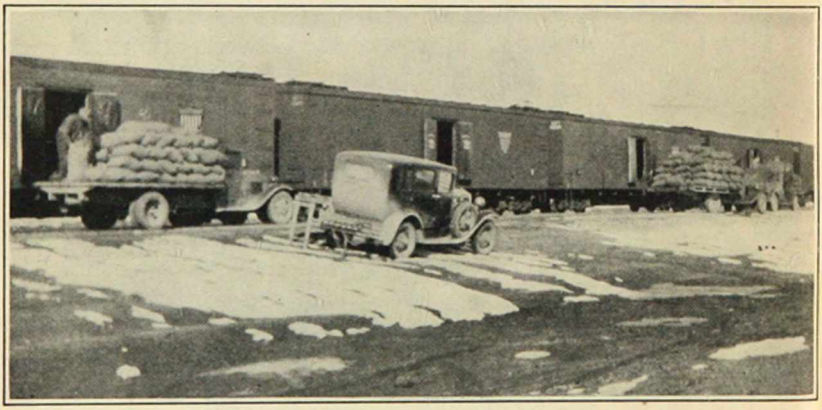

Fig. 66. Loading a few cars in the San Luis Valley. Notice the inspector's car and table.

Commercial, U. S. No. 2 and Unclassified. U. S. No. 1 Grade is not fancy in appearance or difficult to make if potatoes are properly grown and handled.

The grading process is a source of as much injury to tubers according to the Maine investigations* as all the other harvesting operations together. The total percentage in Maine was 43.56 percent of which 7.30 percent was major injury and 36.26 percent was minor injury. The grading process caused more injury than moving to the graders or dropping into sacks. This injury was reduced nearly one-

*Schrumpf, Wm. E., 1933, The Effect of Handling Methods on Qualities of Maine Potatoes, Maine Station Bulletin, 365.

half by padding the graders and padding under the sacks. Inspectors in Colorado also report serious damage from loading cars. Sacks should never be dropped into place but carefully handled at all times.

CLEANING THE TUBERS

Two machines are now on the market which improve the appearance of potatoes. One is a washer which is used very successfully in California. Washed California potatoes topped the markets during the fall of 1933. Maine has been using a brushing machine since 1931. Idaho has also shipped a considerable quantity of washed and "cleaned" potatoes. This competition will undoubtedly force Colorado growers to adopt the practice.

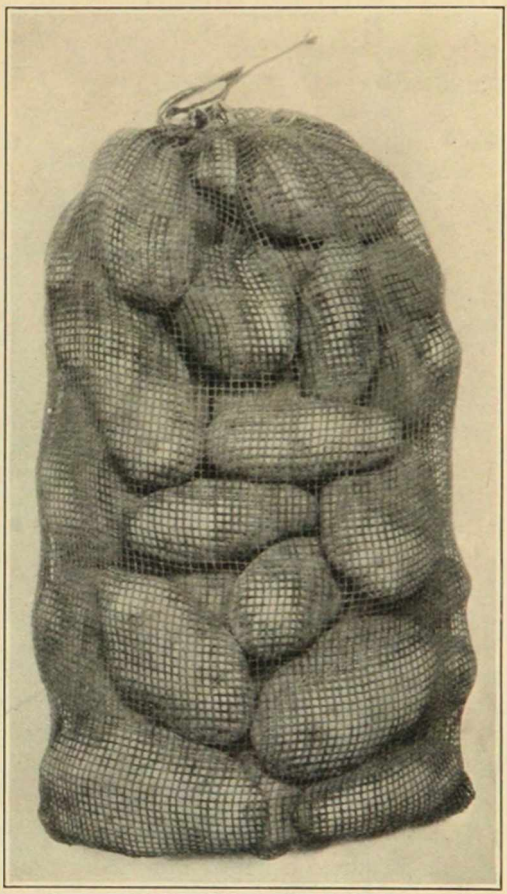

Fig. 67. Small packages are becoming more popular.

Table 23. Distribution of potato shipments from Colorado by states, August 4, 1924, to April 4, 1925.

Destination by State	Cars	Destination by State	Cars	Destination by State	Cars
New York	1	Kansas	1,432	Wyoming	40
Florida	3	Tennessee	24	Colorado	2,440
Ohio	6	Alabama	61	New Mexico	994
Indiana	2	Mississippi	38	Arizona	398
Illinois	133	Louisiana	417	Utah	10
Iowa	4	Texas	2,954	California	17
Missouri	320	Oklahoma	1,328		
North Dakota	1	Arkansas	96	Total	10,767
Nebraska	47	Montana	1		

FUTURE OF THE INDUSTRY IN COLORADO

The history of all the great potato states shows that there is a decline in both yield and quality after the pioneer period is past.

Fig. 68. Trackside storage and grading plant.

Growers then usually seek more knowledge of the crop and a solution for the problems which have arisen. Colorado is past the pioneer, exploration period in most districts. There is considerable evidence to show that the decline has started. In order to stop this decline and protect the future of the industry in the state the following recommendations are made:

1. More humus or organic matter must be put into the soil.
2. Plant certified seed.
3. Produce a better-appearing product by controlling diseases and insects and more careful production, harvesting and handling methods.
4. The yields must be increased to lower the cost of production. The same total yield for the state could be obtained on one-fourth less acreage if better methods were used.