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THE COLORADO POTATO INDUSTRY

BY

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THE COLORADO POTATO INDUSTRY.

A Preliminary Report Based on One Season's Study, Partly Aided by State Appropriation of 1905

E. R. BENNETT

THE POTATO INDUSTRY OF COLORADO has a number of peculiarities. The total yield of the state (8,000,000 bu.) as compared with some of the other great potato producing states is not large. In the East the great yield of potatoes comes not from any one area but for the most part from small acreages on each of the many small farms over the whole of a state. In Colorado the potatoes are grown only in certain restricted and well defined districts. On these areas potatoes are the most important product and the other crops are an adjunct to or an element in the system in the preparation of the land for this crop. It is not an uncommon thing in these districts to see fields of from forty to one hundred acres of potatoes on farms of a quarter section.

The problems confronting the growers in this State, as to cultural methods, insect pests and fungous diseases, are also radically different from those of the Eastern States. Many of the fertile irrigated tracts do not produce potatoes successfully, though they are near and similar in most respects to the so called potato districts. Why this is so has not so far been satisfactorily explained. The writer has spent the past summer in studying the conditions and methods under which the potato is grown in some of the more successful districts and comparing the methods employed at different places. Of the potato producing sections of the State, the irrigated land surrounding Greeley known as the Greeley District, the water shed between the Arkansas and the Platte Rivers known as the Arkansas Divide, a small section of the San Luis Valley, the Valley of the Roaring Fork of which Carbondale is the center and the Uncompahgre Valley are the most important. A few other small mountain valleys produce a limited quantity for the local mining trade.

The Greeley District exceeds all the others as to area and amount of potatoes produced. It is about twenty miles long from northwest to southeast and twelve or fifteen miles wide at its greatest width. It includes about 200,000 acres of land, though probably not more than one-eighth of this tract is ever put in potatoes at any one time. The total yield per year of this tract is from 9,000 to 14,000 cars or 4,000,000 to 6,000,000 bushels.

Comparatively few varieties of potatoes are grown in Colorado. Nearly all the known varieties have been tried at one time

or another and only a few have proved profitable. The districts differ somewhat in the varieties grown owing partly to the market demands and partly to the difference in soils, elevation and length of seasons of the different places.

THE POTATO INDUSTRY

THE GREELEY DISTRICT. Potatoes have been grown in this district since the foundation of the Union Colony in 1870. At first the bottoms of the Big Thompson produced the most, then the "blight," probably Rhizoctonia, became so bad there that practically none have been grown for several years. After the Big Thompson bottoms began to fail as a potato producing section, they were grown in and near the town to the south of Greeley. Then the blight became so bad that few could be raised in and around town which is mostly on the Laurel* sand loam of the river bottom. As the country north and east of town became broken up, the industry was given a new impetus. As the cultivated area grew the production of potatoes increased but was limited both as to area of land devoted to potato growing, and yield, till alfalfa was brought in as a part of the regular rotation about 1886. Previous to that time alfalfa had been grown to some extent but it was not thought possible to break it up successfully. From 1886 on, the yield of potatoes increased and potato growing as an industry became one of the leading occupations of the farmers north and east of the town. Mr. Boyd in his "History of Greeley" written in 1890 says: "the shipments for the past five years from the Greeley District have been from 1,000 to 1,800 cars a year." Now the shipments are from 8,000 to 14,000 cars.

The blight (Rhizoctonia) has given trouble more or less from the beginning. The Colorado potato beetle has caused some loss at times. Mr. Boyd says in his history of Greeley: "In 1889, fourteen thousand pounds of Paris Green were sold at Greeley and Eaton for spraying potato vines for the striped potato beetle." Locusts have occasionally caused some damage. On the whole, adverse conditions have been fewer than in most potato growing sections of the United States and the growth of the industry has been normal and constant.

The history of the other potato districts of Colorado is similar to that of Greeley.

THE CARBONDALE DISTRICT. Potatoes have been grown in the Carbondale District to some extent since its early settlement. Growing potatoes as a commercial industry, however, did not begin till within the last eight or ten years. At present the production

*U. S. Department of Agriculture, Bureau of Soils, 1904.

is limited only by the amount of irrigated land on the mesas and in the valleys of the Roaring Fork and Crystal Rivers. The soil and climate of these valleys are admirably adapted to the growth of potatoes. Owing to the high elevation and the proximity of high mountains, this district has a shorter growing season than the Greeley District and potatoes are planted correspondingly earlier. The soil is for the most part a red or blackish sandy loam on the mesas with a somewhat gravely soil in the river bottoms.

The methods of culture are similar to those practiced in the Greeley District. Alfalfa is rotated with grain and potatoes. One difference in practice is that seed is planted closer. The hills there are nine to twelve inches apart instead of thirteen to fifteen inches. The rows are also a little closer together being from thirty to thirty-six inches apart instead of thirty-eight or forty.

Few places can compete with the Carbondale District either in yield per acre or in quality of the product. The yields per acre vary on the different ranches according to the natural conditions of the soil and the fertilizers and methods of cultivation used but a high average yield is maintained.

Here as at Greeley nearly all the potatoes raised are of the late varieties. Early potatoes do not yield sufficiently well to pay, nor come early enough in the season to bring the maximum price of early potatoes. The most popular variety is the Improved Peachblow, sometimes known as the Red or White McClure. Other varieties are the Pearl, White Beauty, Carmon No. 1 and Challenge. The output for the valley is from 300 to 500 cars, or from 150,000 to 250,000 bushels.

Quite a large per cent of the West Slope potatoes find their way to special markets for hotels and dining car service. The remainder supply the mountain towns or are sent into the same markets as the other Colorado potatoes.

THE SAN LUIS VALLEY DISTRICT. The culture of potatoes in the San Luis Valley is somewhat different from that of the other potato districts of the State. The crop has been grown there since the early settlement of the State. Before the railroad was put through the valley, potatoes were freighted by wagon to Leadville and other mining towns.

Alfalfa is not grown to any extent in the valley but peas take its place in the rotation.

The soil varies in different locations but that on which potatoes are grown is a dark sandy loam underlaid with gravel. Sub-irrigation is practiced here. The gravel contains water at only a short distance from the surface so by running water in shallow ditches twenty or thirty feet apart, the water table is raised so that the moisture is brought to the surface.

The varieties grown are the Monroe County Prize, Rural N. Y. No. 2, Pearl and Champion. The yield is at present about 400 cars. Most of these potatoes are marketed in New Mexico or Texas.

The tendency toward running out is not so noticeable here or at Carbondale as in the Greeley District. In fact the same seed has been kept at both these places for at least fifteen years without deteriorating.

THE DIVIDE DISTRICT. The Arkansas Divide is the only place in the State of any extent where potatoes are grown without irrigation. Conditions cannot so well be controlled and the yield is correspondingly less. A specialty is made of growing potatoes for seed in this locality. As much of this seed is used in the Greeley District the same varieties are grown.

The culture given the crop is similar to the other places except that more surface cultivation is necessary to conserve the limited amount of water though the rainfall is considerably in excess of other parts of the State.

METHODS OF POTATO CULTURE IN THE GREELEY DISTRICT

Owing to the character of western soils, system of irrigation, large acreage of potatoes per farm and rotation of crops, the methods of potato culture in Colorado differ somewhat from those of other sections of the country. At first the methods of irrigation and cultivation best suited to the conditions here were not well understood but since it was found that alfalfa could be successfully broken up and that deep cultivation was most beneficial the methods have not changed to any considerable extent.

There is a prevailing opinion that potatoes require a certain kind of soil. There undoubtedly is a relation between the yield and quality of potatoes at certain places and the different soils. Just what this relation is, however, has not as yet been successfully explained. Good yields of potatoes are produced on several different soils and failures occur on all of them.

SOILS. The soils used for potatoes in the Greeley Potato District are: *Billings loam, Colorado fine sand, Colorado sand, Billings clay loam and to a certain extent Laurel sand loam.

The Billings loam is a heavy soil well mixed with sharp granitic gravel. It has a depth of from two to five or six feet. This soil is underlaid with gravel which gives good under drainage. More care has to be exercised in handling this soil because if worked when too wet or too dry, it is more liable to become lumpy than are the lighter loams.

The Colorado fine sand loam is intermediate between the Billings loam and the Colorado sand. It is generally deeper than

*U. S Department of Agriculture, Bureau of Soils, 1904.

the Billings loam and does not pack or become lumpy so easily as the latter but on the other hand it contains less gravel. These two soils constitute by far the larger part of the successful potato district north and east of the town of Greeley.

The Billings clay loam is finer than either of the others. It has less gravel and is so deep that the under drainage is not good. This soil occupies narrow strips in the creek bottoms and while it often produces good crops of potatoes it is liable to serious attacts of fungous diseases.

The Colorado sand is coarser in texture, contains less nitrogenous matter and requires more water to produce a crop but where proper rotation of crops and cultural methods have been employed, good results are obtained.

The Laurel sand loam, which is the first bottom land of the Poudre River Valley, is not very different from the other sandy loams but in most places the water table is close to the surface and potato growing on this soil in not uniformly successful.

All these soils contain more or less alkali but not enough in most cases to prevent the development of plants except where water stands and evaporates.

PREPARATION OF POTATO LAND. The preparation of the land for potato growing is probably the most important item of the work. The difference between new land broken for potatoes, old land and alfalfa land is most marked. The new land produces a very clean grade of potatoes but does not give so good a yield as land either preceeded by potatoes or alfalfa. Alfalfa land gives the largest yields and is less liable to disease than where potatoes succeed potatoes. The universal practice is to rotate so as to preceed potatoes with alfalfa.

ROTATION OF CROPS. The most common rotation is alfalfa two or three years, potatoes two years or where beets are grown, potatoes one year, and beets one year, then grain two years. Sometimes wheat or oats are only grown one year but experience has shown that in the majority of cases, the first year of grain following potatoes or beets produces so much straw that the young alfalfa is smothered out if grown. The grain, owing to the reduced fertility of the soil, is not so large the second year and makes a better nurse crop for the alfalfa. Another rotation practiced to some extent is alfalfa two years, potatoes one year, wheat one year, potatoes one year, grain, then alfalfa again. This system while not very generally practiced has some possibilities in the way of "blight" control which will be spoken of later in this report. The number of years alfalfa should be allowed to grow to get the land in the best condition for potatoes is an open question.

While by far the majority of growers allow it to stand but

two years, it is the opinion of some authorities and many of the best practical farmers that it would do most good if left three years. Some think that even six or seven years would be better.

Winter sheep feeding has changed the rotation to some extent. When enough sheep are fed to produce a good coat of manure for the potato fields, potatoes are followed with potatoes twice or potatoes once and once with beets. Very substantial gains in yield of both potatoes and beets have resulted where manure has been used. The use of manure on land here as well as in the Eastern states is cumulative in its effects and benefits particularly the heavy soils in two ways. The physical condition of the soil is improved by being made more porous and friable so that it will hold moisture better and of course, plant food is also added to it.

PLOWING. In the preparation of the land for potato growing the plowing is not the least important. This is sometimes done in the late fall but more commonly in the spring from the latter part of April to May 15th. Fall plowing gives good results but ordinarily time for doing the work cannot be found at that season or the land may be too dry to make plowing possible. The depth of plowing ranges all the way from six to twelve inches but nearly as many plow eight inches deep as all other depths taken together. The work is generally done with four horses and a 14-16" plow. When alfalfa is being broken the plows used have a wide share so that all the alfalfa roots are cut off at the bottom of the furrow.

A practice that is to be commended in other places as well as on the irrigated land of Colorado is that of following the plow immediately with the smoothing harrow. This is done partly to mellow the soil and prevent the formation of lumps but mostly to conserve the moisture. Experiments have demonstrated that the loss of moisture by evaporation is much less where this is done than where the plowed land remains for a time without harrowing. In this State the practice is to harrow all the land that is plowed each half-day before leaving the field.

HARROWING AND LEVELING. In many fields scrapers are used after the first harrowing to fill the hollows and take down any ridges that are liable to cause trouble in getting water evenly distributed over the field. The amount of work required to fit the land for planting after the first harrowing and leveling depends on the character of the land. With average loamy soils one or two subsequent harrowings are sufficient to put the soil in perfect condition for planting. If the soil is heavy or has been packed by rains, the disk harrow is used and followed by the smoothing harrow.

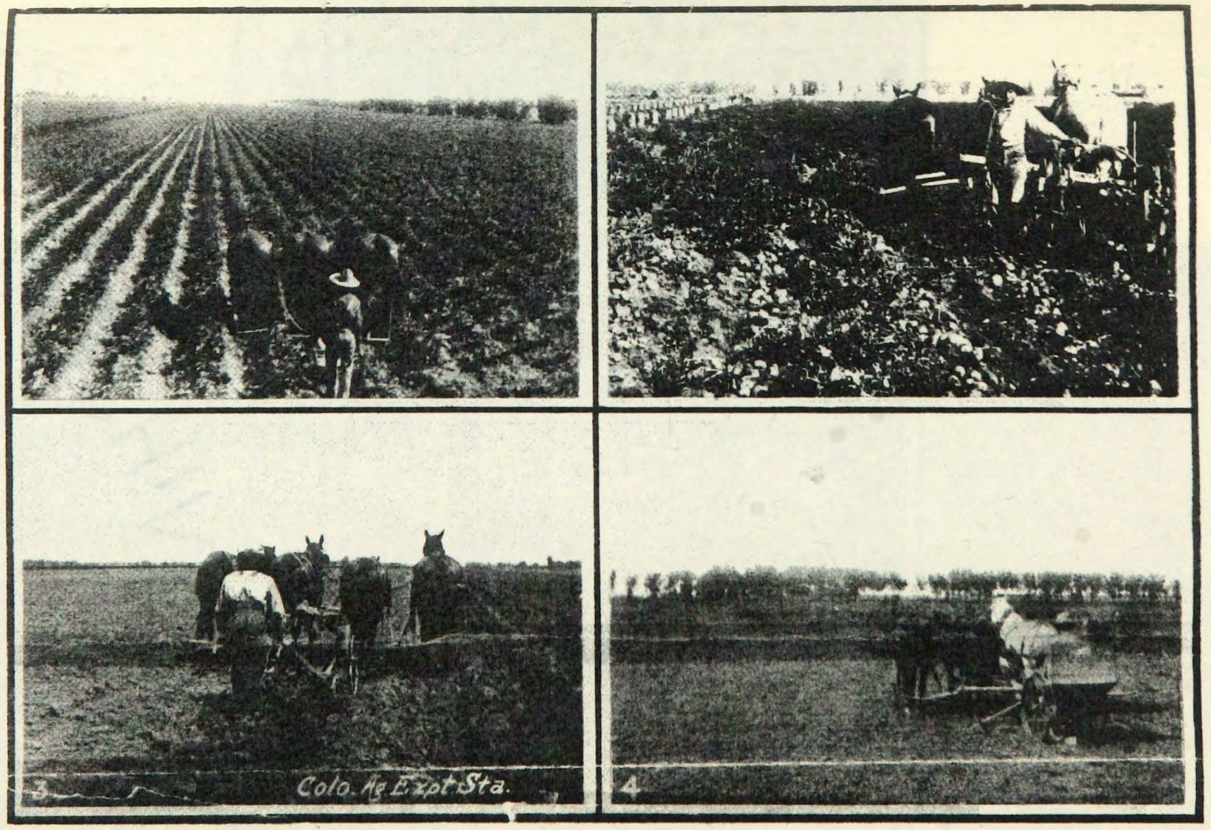

PLATE I. CULTURAL OPERATIONS.

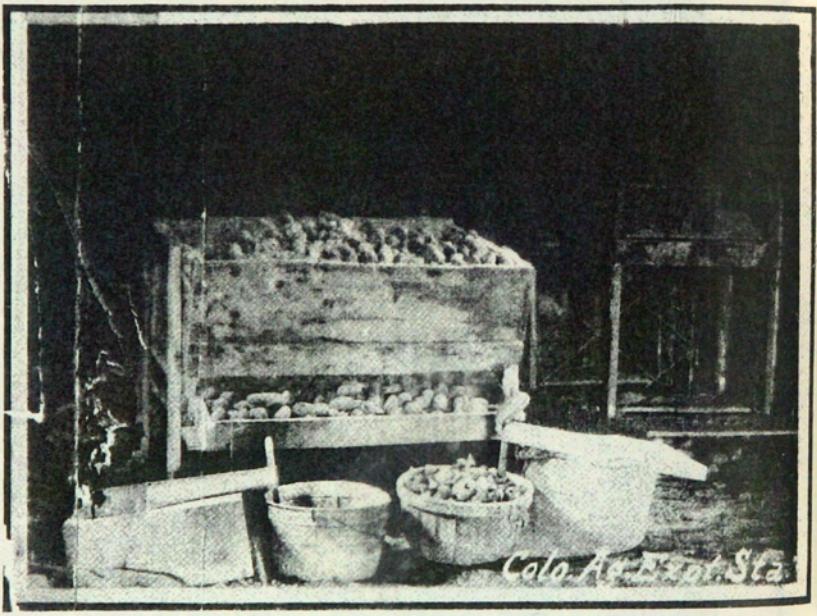

PLATE II. Conveniences for Cutting Seed Potatoes. Notice the Knife in the Board.

PLATE III. Irrigating Potatoes—alternate rows.

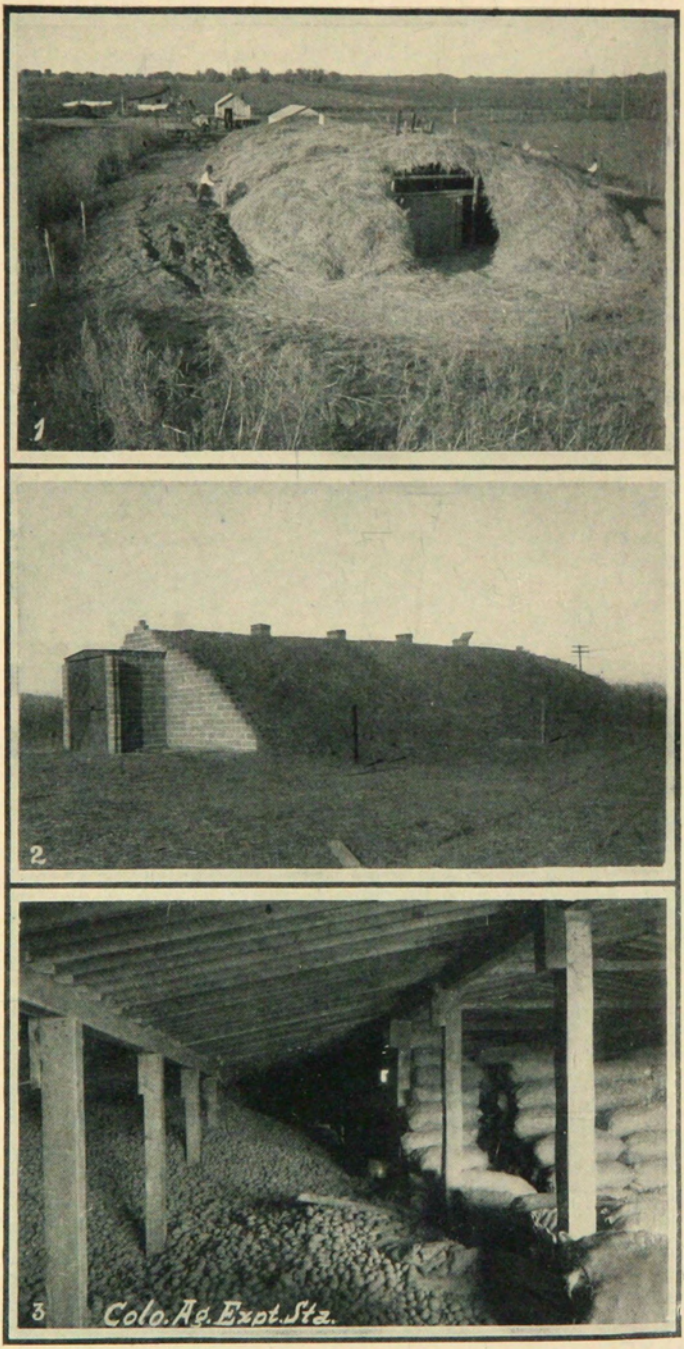

PLATE IV. POTATO CELLARS.

1. Process of Construction. 2. Exterior. 3. Interior.

PLANTING. Much diversity of opinion prevails among the growers as to the details of preparing seed and planting. The general practice is to select seed from the stock which is left over winter in the storage cellar for the spring market if home grown seed is used. If not, the seed is purchased from the Divide country, the mountains or from the East. Medium to small seed is used by the majority of growers. Some make a practice of "greening" the seed. That is the seed is spread in a thin layer on the floor of the dugout a few weeks before planting time. The ventilators and doors are left open to admit the light. Occasionally the potatoes are shoveled over to give a uniform exposure so that by planting time the tubers have become hardened and green, and the sprouts, if there are any are short and green instead of being long, slim and pale. The formailin or corrosive sublimate treatment is seldom used. Cutting is done by hand. The number of eyes depends on the variety as some varieties of potatoes have many eyes while others have few. The usual aim is to leave two eyes on a piece, but the rule is not arbitrary. In fact the work coming at the busy season makes it necessary to employ inefficient help so that some pieces are left with many eyes while others have none. A method of cutting shown in Figure 2, Plate I, is thought to facilitate the work to some extent. The potatoes are shovelled into a bin or hopper made of a dry goods box raised on legs. The back is made higher than the front so that the potatoes will run down to the opening. In the bottom are cracks to let out the soil that is shoveled up with the potatoes. The cutting is simple. An old case knife or a shoe knife is fastened to the end of a piece of plank or board in such a way that the potato can be pushed against the knife and fall from it into the basket beneath. The seed is planted soon after cutting as it is thought that the vitality of the buds rapidly becomes lowered as the seed drys out.

Various substances are used on the cut seed that are supposed to be beneficial by drying the cut surfaces and preventing the work of insects or fungi. Air slaked lime, flowers of sulphur and gypsum (land plaster) are all used by different growers. All these are used in the same way. The cut seed is piled on a floor, the material is scattered on and then mixed by shoveling the pile over till the dust is brought in contact with each piece.

VARITIES. Very few early potatoes are grown. Early varieties have frequently been tried but the yield is seldom satisfactory and the crop cannot be marketed in time to get a high enough price to make up for the deficiency in yield. Mammoth White Pearl leads all the other varities in acreage and generally in yield. Rural N. Y. No. 2 is second in popularity and some

Ohios and Snowflakes are planted. Nearly all the known varieties have been tried in this district at one time or another but none of them have been able to compete with those named. The long potatoes tend to become longer and roughened and in a year or two degenerate or revert to what is supposed to be the ancester of our present race of potatoes. Owing to this tendency for seed to "run out" the same stock is not used more than two or three years.

PLANTING. All planting is done by machinery. Among the different makes of planters used are the Aspinwall, the Evans, the Superior, the Robins and the Excelsior. All these planters require cut seed. Very little difference can be seen in the work of any of them. Four horses are used with these planters and five to seven acres planted is considered a days work. The rows are from thirty-six to forty inches apart, with a distance between plants in the row of thirteen or fifteen inches.

CULTIVATION. Very soon after planting the first cultivation is given. The ridge left by the planter shows the rows so the plants do not need to be seen. The object of the first cultivation is two-fold. First the tramping of the four horses used on the planter packs the ground solidly. This needs to be loosened to areate the soil and prevent loss of moisture by evaporation. Second the alfalfa or weeds that are starting are killed. For this work, four horses on a heavy four shovel John Deere type of cultivator are user. The shovels are set to run as deep in the soil as they will go which is from eight to twelve or thirteen inches. They are also set so as to throw the soil toward the potato rows, thus beginning the hilling or ridging process which is characteristic of potato culture in this locality. This operation leaves the soil loose but more or less lumpy, and with a rough uneven surface, especially on the heavy soils. The harrow immediately follows the cultivator to re-establish the soil mulch. These two operations destroy the young weeds so there is little trouble in keeping the field clean.

The number of cultivations depends upon the weather conditions and rapidity of growth of the vines. The cultivator is used a second time as soon as the plants are large enough so that the rows can be easily followed. This time the shovels are not run quite so close to the row but to the same depth unless the plants are much developed. In that case the inside shovels are raised so as not to injure the root system. Sometimes two cultivations are all that are given but ordinarily a third follows the second by a week or ten days and if the vines do not get too large or irrigation become necessary, cultivation is continued. Each time the cultivator is used more soil is thrown toward the potato rows

and the hollow between the rows becomes deeper, thus ditching is more easily done.

Ditching and irrigating are delayed as long as possible. The rule is not to irrigate if it can be avoided till the potatoes are in bloom or the tubers set.

DITCHING. The ditching is done with a narrow double mold board plow. Three horses are attached and the plow is run once in each row at about the depth of cultivation or ten to twelve inches. This ditching takes the place of one cultivation and if the ground is hard or if the first irrigation fills the ditches to any extent, the operation is repeated so as to make the ditches deep enough to keep the water below the surface of the potato ridges.

IRRIGATION. The details of irrigation depend upon the size and contour of the field to be irrigated. Many of the fields are arranged so that the rows are from one-fourth to one-half mile long. If the land slopes sufficiently and continuously across the field from the supply ditch, the problem is simple. At the first application the water is turned into a lateral at the head of the rows. A canvas dam is placed in the lateral so as to hold the water back and raise it into the rows. After the water has run in these rows a sufficient length of time to thoroughly wet the soil, the canvas dam is pulled out and reset farther down the lateral, and the water is stopped by blocking the heads of the irrigated rows with soil. In large fields the water is run in alternate rows only.

The head of water let into the rows depends upon the slope and length of rows. If the rows are short and the incline steep, the head must be small or the stream will reach the far side so quickly that enough water will not be used to thoroughly wet the soil. On the other hand, if the rows are long and the land nearly level the head of water is increased so as to force it along the rows faster, or a transverse ditch is cut through the middle of the field so as to shorten the distance that the water has to flow. If ridges occur in the field transverse ditches are run along at their top and irrigating is done both ways from it. When the water has run in the ditches till it seeps through to the unirrigated row, the soil is sufficiently wet. At the second irrigation the water is run in the rows not irrigated the first time. As the vines become large, the irrigation becomes more difficult owing to the lodging of the vines in the ditches, till at last considerable trouble is sometimes experienced to get the water through. On the other hand as the vines grow larger the soil is more protected from the sun so that the evaporation becomes less and the plants suffer less from want of water.

AMOUNT OF WATER USED TO GROW POTATOES. The number of applications and amount of water used per acre varies with the kind of soil and amount of rain fall. With average seasons the rain fall for May, June and early July is sufficient to bring up the plants and grow them till the tubers begin to form. Irrigation once begun must be continued at intervals of one week to ten days till the crop is developed. Four or five irrigations unless the season be a dry one will carry the crop through. A wide range of opinion prevails as to the amount of water that is best to use in irrigating potatoes. Most of the successful growers hold that in general too much rather than too little water is used. Some measurements taken on the E. R. Bliss ranch show the amount of water actually used in growing a crop of potatoes both on alfalfa land and on old potato land. The applications on a potato field which was preceeded by alfalfa were made as follows: July 25-26th the water ran 17 hours with a delivery of 4.05 feet per second. August 1 and 2, 27 hours with 1.96 feet per second. August 8 and 9, 24 hours at 2.31 feet per second and August 15 and 16, 30 hours at 2.37 feet per second. In all 893,916 cubic feet of water was used. This field was 1218 feet one way by 639 feet the other. This gives an area of 779,520 square feet or 17.88 acres, and a depth of water used in irrigation of 13.76 inches. The rain fall by months from April till October was: April, 3.04 inches; May, 1.73; June, 1.10; July, 2.24; August, .64 and September, 2.31, or 11.05 inches. The September rain was mostly in the latter part of the month and probably did little if any good to the potato crop. If the September rainfall is left out, the precipitation that should be counted as contributing to the growth of the crop will be 8.75 inches. The rainfall plus the irrigation gives us 22.51 inches as the total water used on the crop. This field had previously been in alfalfa for three years. It is Billings loam soil (clay loam) with quite a large per cent of sharp granitic gravel. The soil is about two and one-half feet deep, underlaid with gravel, so it has good drainage. The field was plowed in early May, eight inches deep, harrowed immediately and planted to Pearl and Snowflake potatoes June 1st. The yield of Pearls on this field was above 150 sacks per acre which is near the maximum for the season.

The field adjacent to this one which had grown potatoes the year before gave somewhat different results as to amount of water required, yield of potatoes and time of ripening.

The applications on this field were just previous to those on the alfalfa land potato field. The first run was 14 hours at a discharge of 4.05 feet per second and the second 18 hours at 1.96 feet per second, the third 16 hours at 2.31 feet per second

and the fourth 24 hours at 2.37 feet per second or a total of 668,232 cubic feet of water. This field was 1,300 feet long by 660 feet wide which gives an area of 858,000 square feet or 19.74 acres, and a depth of water over the field of 9.35 inches. The difference in the irrigating water between the old potato land and the alfalfa land was 4.41 inches. This field was planted just previously to the alfalfa field and the potatoes ripened (or the vines died from Rhizoctonia) about two weeks earlier. The yield was about 130 sacks per acre as against something over 150 sacks for the alfalfa land. Frequently a greater difference than this results between alfalfa land for potatoes and land preceeded by other crops. It would hardly seem that the difference comes from the amount of plant food in the soil for after potatoes have been grown on soil even three years, the cereals grown on it will produce heavy crops.

The difference in the amount of water can be attributed to the physical condition of the soil in the two fields. The decaying alfalfa stems and roots make the land more porous and the first irrigation particularly takes more water to fill the soil.

HARVESTING THE CROP. The potato harvesting is done so far as possible with machinery. The diggers used are the Peter Brown and the Doudon type of machines. With these the potatoes are plowed out and elevated over carriers that separate the tubers from the soil and leaves them scattered on the ground. Four or six horses are used on these machines. One machine will keep from ten to fifteen men busy, depending on the yield, picking, sacking and hauling from the field. While these machines are not perfect, they leave the potatoes well separated from the soil, providing the soil is not too wet nor the vines and weeds to numerous. Sometimes a harrow is run over the field before digging to knock down and tear out some of the vines that would clog the digger. When several rows are dug (depending on the number of pickers) the picking and sacking begins. The potatoes are picked in baskets and dumped onto the sorter. This machine is simply a frame on runners to which a horse may be attached to keep it alongside the pickers. On this frame, two seives, made of heavy wire, are placed, slanting to the back so that the large potatoes that will not go through the upper seive roll down into a sack. The smaller ones go through onto the lower seive which is a finer mesh and roll into another sack while the very small potatoes and soil fall through the second seive to the ground.

If the potatoes are to go direct to the market, the sacks are filled and set off on the ground. A man follows the sorter and with a needle and coarse twine closes the sacks by sewing up the top. The filled sacks are then loaded onto wagons and hauled

to the markets. These sacks are made of coarse burlap and hold from 110 to 120 pounds of potatoes. All potatoes are marketed in this way. Much expense in handling and loss from storing is avoided by this system of marketing direct from the field but on the other hand, the markets are often over supplied and the price reduced, by throwing such a large quantity of potatoes onto the market at one time. With the present conditions, however, the marketing of a large per cent of the crop from the field is necessary owing to lack of storage capacity on the farm. If the potatoes are to be stored in the "dugouts" or potato cellars, the sacks are only partly filled in the field then taken to the "dugout" and emptied into bins.

THE STORAGE HOUSE. The dugout or storage cellar is distinctly a dry climate or western feature. While its principles of construction would not adapt it to places of heavy rainfall, it is not only cheap but most efficient as a storage place for potatoes and other root crops in this climate. Being surrounded by soil on all sides, a nearly constant temperature is easily maintained. The loss from shrinkage by evaporation is also less than in ordinary cellars.

The construction of the dugout is simple. An excavation is made in the ground of the required dimensions for the cellar and of a sufficient depth to give soil for covering the top. A frame of posts, timbers and rafters is then made as for a building. This frame is covered with wire netting or brush. Over this two or three feet of straw is placed and this covered with soil to a depth of six to twelve inches. Figure 1, Plate IV, shows the method of covering the cellar with soil. Ventilator shafts are put in at regular intervals to give air circulation and keep the temperature from rising too high. Most of these dugouts have an alley through the center with doors at either end so that the wagon may be driven through. Double doors with a dead air space between are used as a protection against frost.

These dugouts are often filled to their full capacity in the fall to hold the crop for a rise in price. If they are stored while the weather is yet warm the ventilators and doors are left open nights to give a circulation of cold air and closed during the heat of the day. In this way the bins are gradually cooled down and by giving close attention to the temperature the whole mass is kept as cool as possible without danger from frost. During the winter considerable care has to be exercised to prevent the temperature of the dugout from rising from the heat developed by the stored potatoes. This is regulated by opening and closing the ventilator shafts as the case demands.

MARKETS

The position which Colorado occupies in respect to markets is one of the most important factors in making the industry profitable. Her geographical position is such that advantage can be taken of a shortage of crop either east or west of the mountains. And at the same time she is far enough away from the potato producing central states to avoid, to a great extent, the glutted markets that frequently occur when large crops prevail in the Mississippi valley and in the Lake Region. The cities of the east slope of the Rockies with Texas and New Mexico ordinarily get the large share of the crop but not infrequently the Pacific Coast, Central States and even New York and Boston are markets for the Greeley product. Practically all Colorado potatoes are put on the market in sacks. This system is somewhat more expensive than shipping loose in the cars as sacks cost from $6.50 to $8.00 per hundred. The system of sacking, however, has an advantage in that less time is required in handling the crop and the system is growing in favor in all the potato growing sections.

POTATO PESTS

The insect enemies and diseases of potatoes of Colorado are so different from those of the eastern states that the work done there on this subject is of little value to the Colorado potato grower.

INSECTS. The striped or Colorado potato beetle is a native of this state, yet the damage done by this beetle is now ordinarily so slight that no attention is given it by the growers. The flea beetle is, however, a serious pest. Comparatively little is known of the life history of this insect. There are several species similar in general appearance that do more or less damage. The worst one is the black flea beetle (Epitrix cucumeris). The last of May or the first of June these little flea-like beetles may be seen in quantities feeding on the weeds along the fences and ditch banks. They are black or dark brown, shiny and about one-tenth of an inch long. When disturbed, the insect jumps and disappears, a trick that gives it the name of "flea beetle." How they pass the winter is not known. Their presence is most noticeable by the appearance of the foliage that has been eaten, as the numerous little holes or light spots on the leaves of potatoes as well as tomatoes and the cucurbits are due to them. These perforations in the foliage injure the plant by rducing the leaf surface and also by giving entrance into the leaf of various plant diseases. Just how much the yield of tubers is cut down by this injury to the foliage is difficult to estimate. Later in the season the insect deposits eggs on the underground stems of the plants. The lar-

vae soon appear as very small white worm-like bodies on the potatoes or underground stems. These larvae are slender and from an eighth to one-fourth of an inch long. If tubers are carefully taken from the soil early in the season where these insects are prevalent, the larvae may be found burrowing into the tuber about one-third of the body being inside. At a casual glance they appear not unlike short root hairs growing from the surface. The injury caused by this insect produces the pimply effect so often seen in potatoes on the market and is often confused with or may be classed as one of the forms of scab. No practical remedy is known for this insect in this state. Spraying with Bordeaux mixture and arsenites destroyes or repells them but the expense of application of this remedy prohibits its use under the system of growing used here. When potato planting is delayed till June first, the injury to the foliage is avoided to some extent for by the time the plants are up the insects have sought other feeding grounds.

This insect is quite generally distributed over the country but is more prevalent in some places than in others and is also more numerous some seasons than others. The past season they have been particularly numerous, probably owing to the preceeding mild winter.

Not infrequently scabby or injured potatoes are infested with numerous small white worms so that there is quite a general opinion that the scabbiness or injury is caused by them. This is not usually the case. The injury or scab is caused by some other agent and the worms, which are saprophitic, work in the dead tissue and by so doing are credited with the damage. When earth worms are particularly plentiful the potatoes may be made dirty as a result of the worms crawling over them and leaving a slime to which the soil sticks.

FUNGOUS DISEASES. The fungous diseases of Colorado potatoes differ widely from those which cause the serious losses of the East. Early blight (alternaria) can be found but so far as is known little or no damage has resulted from it. The late blight (Phytophthora infestans) has never appeared at all.

CORTICIUM VAGUM B. & C. (*Rhizoctonia*). The serious fungous pests of Colorado are mostly those that work below ground. Bulletins Numbers 70 and 91 by F. M. Rolfs describe the one fungous disease that causes most of the loss to potato growers of this state. This disease evidently is not new to this locality for Boyd in his History of Greeley in speaking of the potato industry during the Seventies says: "For the first two years potatoes did well near Greeley on this side of the river. For some twelve years none could be raised in and around town. They did, as a rule,

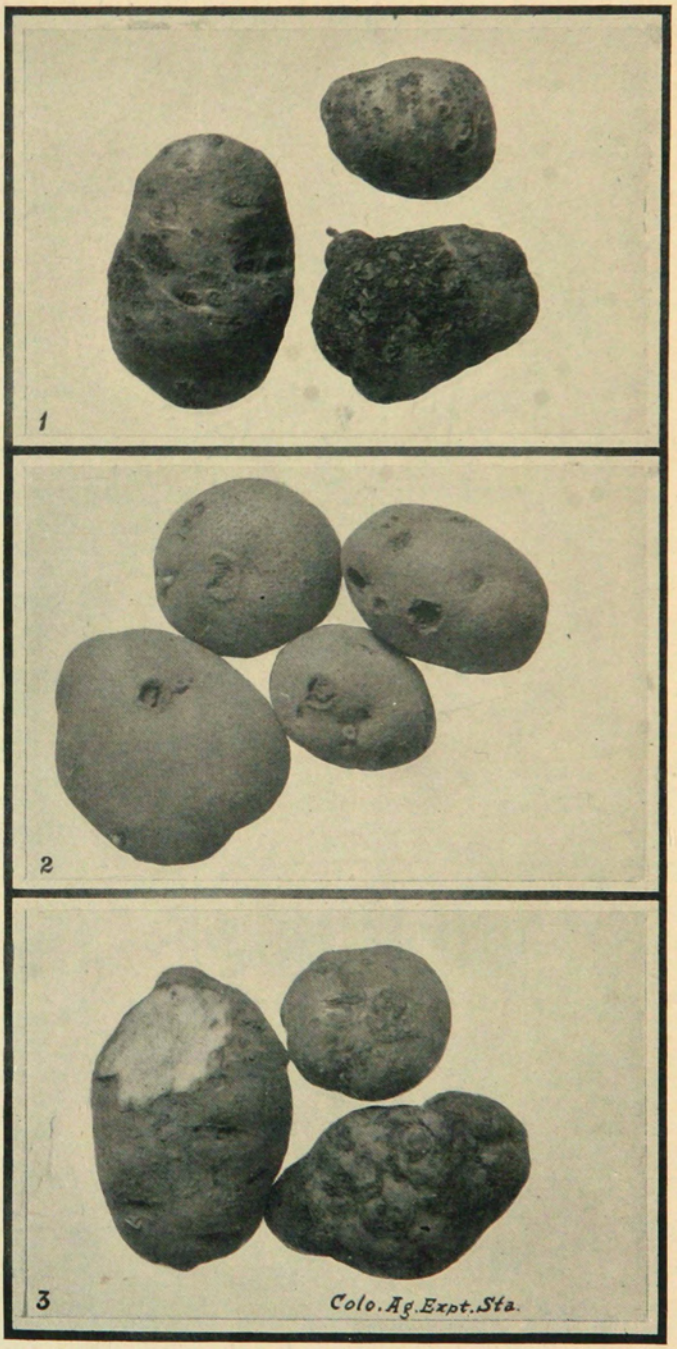

PLATE V. SCAB OF POTATOES.

1. Surface Scab. 2. Deep Scab. 3. Apparent Scab—work of the Beetle.

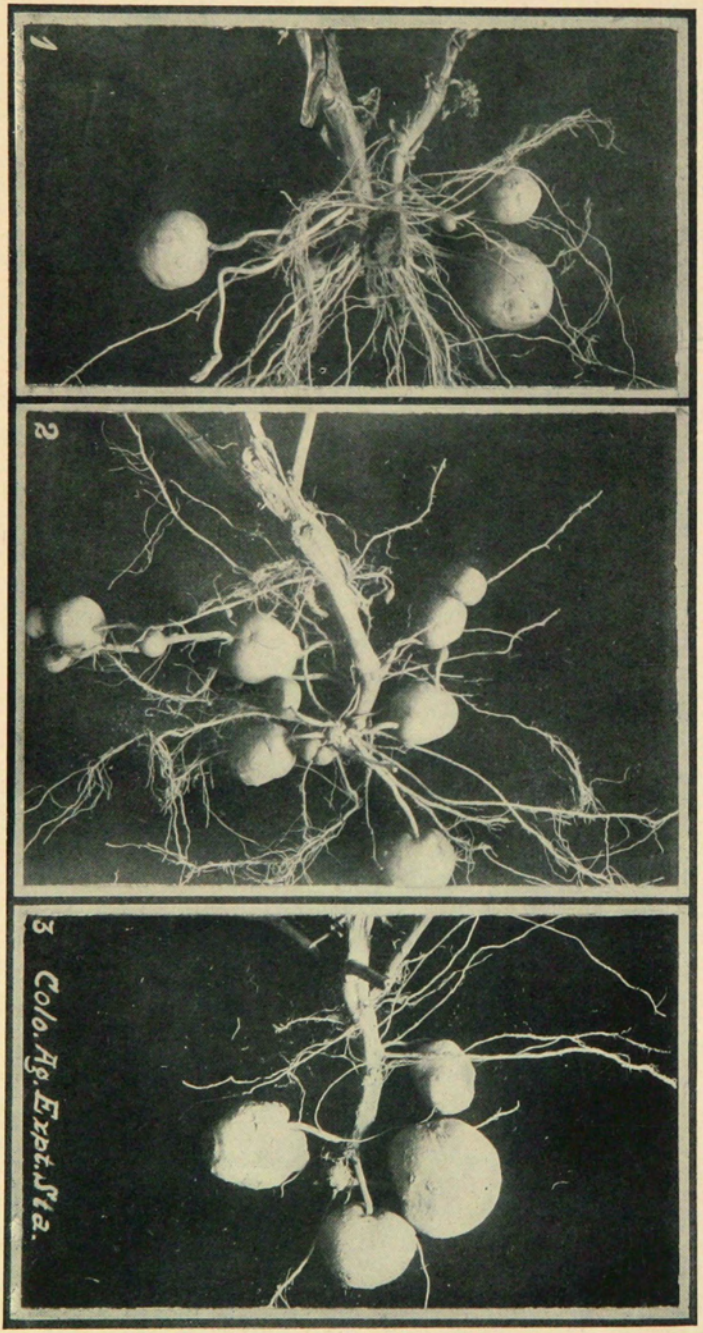

PLATE VI. HABITS OF GROWTH.

1. Rural N. Y., No. 2. 2. Improved Peachblow. 3. White Pearl.

no better on newly broken sod than on old sand. Heavy manuring of the land did not help the matter. The vines were struck with a rust or blight. This fungus made the leaves thick and stiff, and undoubtedly destroyed the sap and prevented the leaves from carrying on their function."

This is a good superficial description of the effects of this fungus as it looks in the field. From its past history it is evident that meteorological conditions have a strong influence on the behavior of this fungus. Probably there has been no year since the growing of potatoes began in this State that the disease has not been present, but much of the time, at least in the more favored locations, its attacks have been so light that it did not attract the attention of the growers. A high temperature, excessive moisture, alkali and a compact soil are all conditions that probably favor the development of the fungus. It has been generally supposed that this disease is introduced into the fields with the seed potatoes as nearly all seed tubers have more or less of the fungus on their surfaces in the form of scab or the black dirt-like patches of the sclerotia stage of the disease. Experiments with treating the seed with formalin and corrosive sublimate show, however, that the disease occurs just the same whether the seed is infected with the disease or clean. This fungus is not confined to the potato plant alone. In fact it is not known just how many plants act as a host for it. Peas, beans, beets, alfalfa and many weeds are known to be subject to its attacks. The curious fact remains that though the fungus works on alfalfa, potatoes following alfalfa are not generally as badly diseased and produce a larger crop than when they succeed themselves.

GENERAL APPEARANCE AND EFFECTS OF THE FUNGOUS ON POTATOES. To the ordinary observer, this disease does not become noticeable till the middle or latter part of the growing season. If the plants be examined carefully at any time from the first sprouting of the seed till the harvest, some of them will be found affected with the fungous. Plate II of Bulletin No. 92 of this Station shows the appearance of the disease in the first stages. Not infrequently if missing hills are examined at the time the plants are breaking through the ground the sprouts will be found to have started, but the stems have been girdled with a brown or black canker that stops growth. But if the injury is not serious enough to kill the plant at this stage, it will have a sickly yellow appearance and die soon after getting through the ground. From the time the plants first come up, all through the season, here and there through the field, will be found what the growers call "blighted plants." The leaves are thickened, and with the White Pearl especially, the leaves draw up close to the

stem so as to show the under side and give the ends of the vines a rosette appearance. Microscopical examination of the foliage or upper stems of these plants shows no traces of disease. If the plant be pulled from the ground, the stem will frequently be found scabby, black, or rusty with the center of the stem discolored. If the attack is unusually severe or in the last stages, the whole stem may be entirely decayed below the surface of the ground. In other cases the bark of the stem may seem fairly smooth and clean, but a split stem will show a discolored center. In this case the disease has started at the base of the stem, that is, at the junction of the stem and the old seed. Sometimes healthy looking vines will have rusty canker spots on the stems and no apparent injury result. It appears to be only those vines that are either entirely girdled or those diseased on the inside that are destroyed. The fatal effect on the plant of this disease comes from the hyphae of *Rhizoctonia* crowding into the cells of the stem and stopping the circulation by clogging. In cases where the disease works only on the outside of the stem, large vines with no potatoes are frequently produced or sometimes little potatoes are formed at the axils of the leaves all along the stems. The past season has been unusually favorable for the development of the disease. The loss from it in this state was probably not less than two and a half or three million bushels. The writer found here and there diseased plants in all fields visited during the early part of the growing season. Diseased plants gradually became more numerous, as the season advanced, but were not numerous enough to be considered a menace till the latter part of July, and the first of August, when a large part of many fields showed the disease. By the last of August growth had stopped in nearly all the fields and hardly a plant could be found that was not more or less diseased. Great variation in yield resulted. Fields of Pearls that developed early, yielded one hundred and fifty or more sacks per acre while other near by fields, particularly Rurals, did not exceed thirty sacks per acre. The question of yield this year seemed to be simply a matter of how far the tubers were developd when the growth was stopped by the fungus.

Experiments in the laboratory have proven, that at least a large part of the so called scab of potatoes in this state is a direct result of the action of this fungus. Sometimes it attacks the tubers causing a greater or less degree of scab without causing any apparent injury to the vines. Again both the vines and tubers are affected and frequently the vines are destroyed and no scab will appear. Some localities are so subject to the disease that potatoes can seldom be produced at all.

Why the fungus develops these peculiarities, what conditions

make it more prevalent in some localities than in others, and what remedies or methods of culture will prevent the loss from this disease are problems that are yet to be solved.

TREATMENT. Some experiments were made with treatment of soils with copper sulfate at the rate of thirty-five pounds to the acre to test its value as a preventative of the trouble. No effect either way could be detected. Cultural methods employed by different growers have also been carefully noted but with no definite results, other than that all the fields that produced satisfactory yields were given deep cultivation, while the small plots, as those planted in gardens even in the most successful potato growing districts, that were cultivated with one horse or kept clean with a hoe, produced nothing. Many fields that received deep cultivation were also failures.

SUGGESTIONS TO THE GROWERS

Although the potato industry of Colorado is new and only partly developed, the reputation of the product for high and uniform quality is known in all the markets of the country. Few places have the natural advantages for producing the high grade product that the irrigated potato sections of Colorado possess. Because of the high altitude the season is comparatively short without extremes of heat. The nights are cool. The amount of moisture can for the most part be controlled and the soils are deep and rich. All these conditions give the grower an opportunity to produce in the potato the same standard of excellence that is maintained by the fruit growers of the West.

We are not prepared to recommend many changes in the methods of culture practiced in the potato growing sections of this State, as those already in use are the results of a number of years experience in the application of scientific principles of soil management to a system of farming that is hardly known in the East. Undoubtedly the greatest need among the potato growers is organization. This is particularly true of the Greeley District. The compactness of the district, value of the property and large output of the crop, are factors that might make a growers organization there, a success, where in a more scattered or less wealthy community, good results would be less easily obtained. It is not our purpose in this report to suggest or recommend any scheme of organization. The advantages to be gained are many. At present there is no uniform system of grading. Scabby or misshapen potatoes may be put on the markets with the best grades. There is nothing to hinder potatoes from any place being sold as Greeley potatoes. With a registered trade mark and a uniform system of grading this could be prevented and the association

label on each sack would be a guarantee of quality, as is that of the various fruit growers associations in the West. Comparatively few consumers have any knowledge of varieties in potatoes. The people who buy Greeley potatoes and get a certain color and quality expect to get the same thing at the next purchase. If many varieties are grown and all go under one name disappointment is sure to follow and the reputation of the product is injured. Only a few varieties are now grown. One or two of these do better than any of the others so there is little reason for growing any but these standard varieties for the general market.

SEED TREAMENT

Results from the use of formalin or corrosive sublimate treatments have not been such that we can recommend their use. Both substances have caused more or less trouble from retarding the germination of the seed and in some cases the seed has been killed by their use. In these cases it is probable that the material was used too strong or the seed was left in the solution too long. Granting that the use of these materials will clean the seed of infection of the scab, the treatment is practically worthless so long as the soils are contaminated with the fungus. The so-called "greening" of the seed potatoes as practiced by some growers in the Greeley District is undoubtedly beneficial.

The treatment of cut seed should receive more attention than it ordinarily does. It is a well known fact that cut seed, allowed to stand for any considerable length of time, shrivels badly and the buds become weakened. Treating the fresh cut seed with air slaked lime, land plaster or sulphur tends to form a crust over the cut surface so as to prevent drying to some extent and they also tend to prevent the action of various fungi, worms and insects. These materials have not been experimented with sufficiently to know which of them is the best, but so far, observations of results have led us to favor the use of the flowers of sulphur as being more repellant to disease than the other two.

POTATO MACHINERY

The subject of machinery is one of general interest. All machines do fairly good work but none have been perfected. Nearly all the machines used in the state are made in the eastern states and are adapted to the conditions there. Some of the later models of planters are improvements on the older styles but none of them get a perfect stand of plants. Much depends upon the depth that it is desired to plant, and the depth of planting depends somewhat on the variety to be planted. Varieties differ consider-

ably in their habit of growth. Tubers are borne on root stocks or under ground stems that always grow from the stem of the plant above the old seed tuber. Figures 3, 1 and 2, Plate VI, show the characteristic habit of growth of Pearl, Rural N. Y. No. 2 and Improved Peachblow. The Pearl sends out short root stocks just above the old seed so that the tubers are formed closely around the center of the hill and at about the depth that the seed is planted. Rural N. Y. No. 2 has a longer rootstock and is apt to start higher above the old seed so that the tubers are more scattered in the hill. Some of them are deep in the soil and others will be close to or at the surface of the ground. The Improved Peachblow is still more irregular in its habit of tuber growth. These peculiar habits of growth make less difference under the hilling system of culture employed in the irrigated districts than where the level system is practiced.

With most machines the seed is planted too shallow rather than too deep. Many potatoes that are supposed to be planted four or five inches deep are really not more than one or two inches under the level surface of the soil. If the soil is sufficiently moist this does no harm but if the soil is dry at the surface, a poor stand is apt to result.

ROTATION OF CROPS AND RHIZOCTONIA

The rotation of crops as practiced in this state does not tend to lessen the amount of disease. The Rhizoctonia which causes the blight and a greater part of the scab of potatoes works on alfalfa as well as potatoes. So far as is known the disease does not live on the cereals so that is has been suggested that if potatoes could be preceeded by wheat or oats, instead of alfalfa, the amount of the disease might be lessened. The efficiency of a rotation of this kind is doubtful, however, as it is probable that the disease lives in the soil more than one year without any host plant, moreover the loss of the beneficial effects of alfalfa upon the soil would possibly be more than the ordinary loss from the disease.

SELECTION

A large part of the improvement in plants has been brought about through selection. This applies to plants propagated by vegetative parts as well as those propagated by seed. All the domesticated species are originated either from crossing or variations and are fixed in their particular characteristics by selection. The different varieties of a species may be called the variations of that species. When a variety is planted year after year it is sure

to revert or change its characteristics (that is run out) if selection of seed is not practiced. This is particularly true of a species that has such a great number of varieties as the potato. Varieties in this way are frequently subdivided into types. In a small way this may be seen in any potato field. A good example may be found in the Improved Peachblow. Some hills will be found that have from one to three large tubers with possibly a few very small ones. The large ones are apt to be cracked so as to be unsalable. Other hills may have one large tuber with several others grading down to the very small specimens. Now and then will be found a hill with from eight to a dozen medium sized perfect shaped tubers. Every man has in his mind an ideal type of the variety that he grows.

HOW TO SELECT SEED POTATOES

When digging, hills will be found, all the tubers of which will conform to this ideal. If these tubers be saved and planted, a large part though not all of them ought to produce potatoes like the seed. These should be selected again by hills and all should be discarded except potatoes from those hills which approximate the ideal type.

The longer this selection is carried on, the greater should be the proportion of tubers like the original selected type.

The usual objection to this selection, in practice, is that at digging time when the work must be done, the grower is too busy getting in the crop to take time for improvement of future crops. The selecting can be done, however, without taking a great deal of time. When the digger is running, one man should follow with a basket and select the most desirable specimens of tubers from hills that conform to his ideal type of that variety. Ordinarily the machine will leave the tubers in such shape that the individual hills can be separated. In this work do not look for perfect tubers only. Select perfect tubers from hills in which *all* of the tubers are of good shape and of sufficient number to give a good yield even though some of them are too small for market.

With this system of selection enough seed potatoes ought to be secured in one day to plant at least one acre of land. These potatoes should be sacked, *labeled* and put in a cool place by themselves. The following spring they should be planted at one side of the field where they can be staked off from the rest of the crop. Most growers prefer to plant potatoes, that are intended for seed, late. A very rich soil is not desirable for growing seed potatoes because of the tendency to produce overgrown tubers. This may be overcome to some extent by planting more seed to the hill or planting the hills closer together. When digging time comes the

same process of selection and elimination should be gone through again. In this way the improvement of type and yield may go on from year to year.

Many growers prefer green or immature seed to that which is fully developed. Experiments along this line with plants produced from seed rather than by vegetative parts have shown that immature seed tend to produce an early maturing plant and also one that tends to produce more fruit to the amount of plant tissue but at the expense of vitality and size of plant.

This law does not necessarily hold good with the potato since the reproduction is accomplished by means of the vegetative portion of the plant. Experiments along this line with the potato have not been carried far enough to give definite results.

COST OF GROWING

The cost per acre of growing potatoes varies to a considerable extent according to the soil, season and price of labor. One year with another an average of the different farms would not be far from the follwing figures which are taken from a pamphlet issued by the Greeley Commercial Club.

Plowing land	$2.50
Leveling and harrowing	1.00
Seed Potatoes	5.00
Planting	1.50
Cultivating	2.50
Irrigating	1.50
Digging	7.50
Sacks	7.50
Marketing	6.00
	$35.00

This estimate is based on what is considered a good yield or from 200 to 300 bushels per acre. The first six items are practically uniform, whatever the yield may be, while the last three depend upon the yield per acre, so that a poor yield or a failure, reduces the cost per acre by about one half and an extremely large yield increases it accordingly.

The price of Colorado potatoes has a wide range from year to year, but the average price for the past ten years has been 65c per hundred lbs.