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CELERY PRODUCTION IN COLORADO

By A. M. BINKLEY



Harvesting, trimming and field packing Golden Self-Blanching celery for market shipment near Denver.

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CELERY PRODUCTION IN COLORADO

By A. M. BINKLEY

Celery is one of the most important vegetable crops grown in the United States and while at one time it was considered a luxury, it is now generally used in the everyday diet. It is now available on the market during the entire year and the consumption increase is due largely to the better understanding of the importance of vegetables in a balanced diet.

The production of celery in the United States has increased rapidly during the past 10 years. California, Florida, Michigan, New York and New Jersey are the principal producing states. Colorado ranks sixth. The largest increase in acreage planted in recent years has been in California and Florida. Other changes have been the sudden appearance of Utah and Idaho among producing states. Previous to 1928 these two states were not listed.

The purpose of this publication is to present information that can be used by the inexperienced celery grower. The discussion of the different phases of celery growing is made in a general manner since methods differ in the different districts of the state, due to the variations in length of growing seasons.

Production of Celery in Colorado

Celery has been grown in Colorado over a 50-year period during which time growers and seedsmen have selected and developed many high-quality strains of the Giant Pascal variety. The state is favorably located and has many natural climatic advantages that favor the production of celery unusually high in quality. Wherever first-grade Colorado celery is sold in competition with that grown in other states, it sells favorably and the difference in quality is outstanding.

There has been a large increase in acreage planted in the state during the past 10 years but under present conditions, it appears as tho the saturation point has been reached, unless more profitable markets can be developed. The following table on production shows that the average yield per acre has decreased with the increase in acreage planted. This is partly due to diseases that have become more common and destructive and to the scarcity of barnyard manure for fertilization. There is less fertilizer applied than formerly and celery requires a fertile soil for profitable production. The increase in wilt or yellows disease in the old celery soils has made it necessary for many

growers to change to new soils each year. The development of more resistant strains is being carried by the Colorado Experiment Station, and in a short time the resistant types should reduce losses caused by celery yellows.

Production In Mountain Valleys.—The question is often asked concerning the possibilities of celery production in the mountain districts. There is plenty of land available for acreage increase in the state; however, profitable markets must be developed first. Celery can be grown in the mountain valleys of the state as has been demonstrated on the mountain farm substation located at an elevation of 7600 feet above sea level. Both the late and early varieties have been grown successfully and the quality and yields were satisfactory. The high cost of growing the crop, the experience necessary to handle it properly, and the necessity for the development of more profitable markets will prevent any increase in acreage at present. Other problems, such as winter storage, have not as yet been worked out satisfactorily for the mountain valleys.

Table I.—Celery Production in Colorado*

Year	Total Production in Crates	Total Acreage	Total Cash Value	Yield Per Acre, Crates
1924	248,000	720	622,000	315
1925	386,000	920	1,220,000	420
1926	232,000	940	344,000	300
1927	232,000	940	479,000	300
1928	270,000	900	702,000	300
1929	264,000	1,100	290,000	240
1930	247,000	950	222,000	260
1931	209,000	950	351,000	220
1932	209,000	950	153,000	220
1933	214,000	950	299,600	225

*From U. S. D. A. Yearbook, 1932, and Crop Reporting Service.

The largest acreage of celery is grown in the vicinity of the larger cities in the state. Near Denver, in Jefferson County, the acreage in 1932 amounted to 260; Adams County produced 250 acres, and Arapahoe County, 10 acres. In the district near Pueblo the 1932 acreage amounted to 260; Canon City produces 110 acres annually, while in Grand Junction only 10 acres were recorded. The balance of the celery acreage is distributed over different parts of the state with El Paso County producing about 10 acres each season.

The increase in acreage has been quite steady and the crop is not as subject to large increases such as we have on other vegetable crops. This is due largely to the intensive nature of the crop and the exacting cultural requirements necessary for profitable production.

Cost of Producing One Acre of Celery

The following table is the result of a 1-year record on the cost of growing an acre of celery in the southern part of Colorado. It is included for its comparative value only since it would require a compilation of many individual records over more than one season to secure an average cost figure. Labor costs were higher than at present, as were also land values. The land was double-cropped so that taxes and interest on the investment are listed only at one-half. Labor costs in other districts will vary, and land values and methods of handling as well. It should be observed that hand cultivation was used in place of horse cultivation. Trenching costs have not been included.

Table II.—Cost of Producing One Acre of Celery, 1926

			Per Acre
LABOR COSTS			
Man labor, 486 hours at 30c		\$145.80	
Horse labor, 26 hours at 10c		2.60	
Contract			
Cutting, bunching, packing, at 9c per doz. (includes crates)	\$234.00		
Wrapping 20,000 at \$1.50 M. (including paper)	45.00		
Hauling at ½c per doz.	13.00	292.00	\$410.40
MATERIALS			
Manure (contract)		44.00	
Plants, 56,000 at \$4.00 M.		224.00	
Water at 70c per A. (½ to celery)		.35	
			268.35
OTHER COSTS			
Interest on investment, \$1500 at 6 percent (½ to celery)		45.00	
Taxes at \$32 per A. (½ to celery)		16.00	
Machinery		.59	
Overhead 10 percent of materials and labor		70.88	132.47
Total cost of production			\$841.22
Total cost per acre			\$41.22
Total cost per dozen (2500)			1.34

*The material on cost of production of celery was furnished by Thos. H. Summers, Senior Extension Economist.

Another record is given for 1928, kept by a different grower in the same locality. This land was not double-cropped. This record shows horse cultivation instead of hand cultivation which partly accounts for the lower cost per acre. Trenching costs also are included.

It must be remembered that these men are experienced celery growers on highly productive land.

Table IIIA.—Cost of Producing One Acre of Celery, 1928

LABOR COSTS		Per Acre
Contract		
Setting plants, 34,000	\$22.00	
Cultivating, 8 times	12.00	
Irrigating	20.00	
Wrapping to blanch at \$2.00 per M.	68.00	
Putting in pits for winter	53.00	
Trimming out	50.00	
Plowing, harrowing and discing twice	18.00	
Preparing ground for setting	3.00	\$246.00
MATERIAL COSTS		
Manure, 20 loads at \$3.00	60.00	
Seed and growing plants, April-June	25.00	
Crates, ice and paper packing	78.90	
Paper and twine	40.00	
Billing, stamps and paper envelopes (est.)	1.10	205.00
OTHER COSTS		
Rent, \$40 per acre cash	40.00	
Equipment, truck use*	7.25	
Overhead (10 percent of materials and labor)	45.10	92.35
Total cost of production		\$543.35
Total cost of production per acre (1 acre)		543.35
Total cost of production per dozen		.192

*Balance of equipment figured in contract labor.

Celery Soils in Colorado

In Colorado celery is grown on a wide range of soil types. The majority of the acreage, however, is planted on the low land benches along the rivers where the soil is usually of the heavier-type loams, comparatively high in organic matter and within 4 or 5 feet of the water table. Celery will grow on nearly any type soil that is well drained, deep, of a somewhat loose texture, and one that contains plenty of available plant food. Under our climatic conditions it is necessary that the crop be supplied with plenty of water during the growing season and especially so in the early part.

The common mistake of new growers is to attempt to grow celery on poorly drained, wet land containing considerable amounts of surface alkali. Celery will not grow well on such soils, as this condition will produce stunted plants, and usually diseases or rot will eventually destroy the crop. On soils that have poor under drainage, there is a continuous moisture evaporation from the surface of the soil which will produce an accumulation of alkali on the surface and generally will not produce a profitable crop. Under such conditions tile drainage should be used, which will keep the soil moisture moving downward at least to a depth of 2 or 3 feet from the surface. It is advisable

to lay the tiles at a depth of at least 3 feet. In some instances growers have used an open drain ditch to carry off the water from seepy spots in the field. In most cases it is far better to tile drain; then the undesirable ditches thru a field will be eliminated.

Fertilizers

One of the most important points to consider in the growing of celery is that of soil fertility. During the past 10 years there has been considerable difficulty experienced by growers to secure sufficient manure for their celery soils. This has had a material effect in reducing the yields of the crop and a good many inquiries are received concerning the methods of maintaining fertility.

Celery as a crop is very shallow rooted and is considered a poor forager. In order for the crop to make a good growth plenty of plant food must be present in an available form for the crop. It is advisable to apply 15 to 20 tons of well-rotted or decomposed manure, preferably in the fall of the year, so that it will be in a form that can be used by the plants during the following season. Fresh manure is not as desirable. Where manure cannot be secured, a green crop turned under as green manure may be used as a substitute in order to supply the soil with the necessary humus or organic matter. This should form the basis of a soil-building program and the commercial fertilizers should only be used to supplement the application of manure or the turning under of a green-manure crop.

Commercial fertilizers have been used on celery and, so far, experimental trials have not produced sufficient increases in yields to make any general recommendations. Before any commercial fertilizer is applied to the soil, it is recommended that a composite sample of the soil be secured from the field and sent to the Soils Laboratory for analysis so that definite information can be secured on the deficiency of your particular soil.

Commercial fertilizers may be applied in two ways. First, the fertilizer may be drilled in with an ordinary fertilizer drill just previous to the final preparation of the field before planting, or second, it may be applied as a side-dressing along the side of the row in shallow furrows about 3 inches from the plants. The first method is generally considered to be the most economical and satisfactory for this crop.

The Preparation of the Soil

There are usually two main crops of celery grown in the state, the early crop and the late crop. Where weather conditions

are favorable and the arrangement of the fall work is properly handled, fall plowing should be used in the preparation of the seedbed. Under the semi-arid conditions of the state there is considerable evaporation of moisture from the soil, and it is advisable in most cases to follow each day's plowing with harrowing. This will break up the clods and create a surface mulch which is coarse enough to prevent blowing. The plowing should be at least 10 inches in depth. The most of the celery land is spring plowed at a good depth, and the greater part of the late crop of celery is grown on spring-prepared land. Since celery is a poor forager, it is much better to disc the manure under in the fall of the year, which will give it a longer period to decompose and in the spring there will be much more available plant food ready for the crop.

Ordinarily, manure turned under with the spring plowing has not had an opportunity to decompose and break down into readily available plant food.

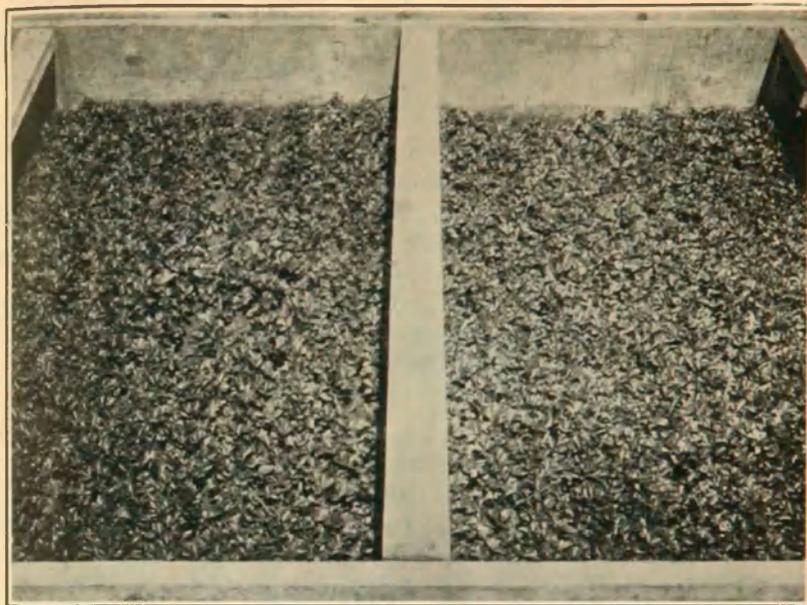
Another advantage in fall plowing is that with the planting of the late crop, the land is already prepared and a preliminary crop such as spinach or head lettuce can be grown previous to setting out the celery. When weather conditions are backward or such that work is delayed in the spring, it also permits the earlier setting out of the early crop.

Growing Celery Plants

The growing of celery plants is an exacting operation requiring careful attention to detail. Since the seed is very small and slow to germinate, it is better to purchase new seed each year since the seed loses its vitality quite rapidly. In case seed more than 2 years old is used, a germination test should be run to determine the viability and the extra amount necessary to sow for a good stand.

The majority of the celery seed for the early crop is imported into the United States for the commercial plantings. At the present time there are quite a number of seed companies and seed growers who make a specialty of selecting high-grade celery strains for the trade, and there is considerable improvement to be observed in this practice. In the sections near Denver, and in the southern part of the state, a few growers produce their own seed from selected individual plants for their late Giant Pascal plantings. Most of the celery growers, however, purchase seed from the seed companies.

The main precaution the grower has to observe in the mat-



Celery plants in hotbed.

ter of obtaining good seed is to purchase his supplies only from reliable dealers. The only other way he has is to plant the seed and take a chance on the crop. As a rule, that is risky business.

Some growers follow the practice of buying a small sample of seed from a firm or dealer who is advertising a specially selected new strain, and trying it out a year in advance of planting in any large quantities. Such novelties or new introductions should be tried out in this manner while growing the commercial crop from old standard varieties purchased from reliable seedsmen.

Time of Planting.—The seed for the early crop is sown about the first part of March, usually in hotbeds so that the plants will be ready for setting out in the field about 10 weeks later. For the late crop the seed is sown about the middle of April in hotbeds, coldframes or outdoor nurseries and the plants in this case are usually ready to set out in the field the latter part of June. When the growing season will permit, outdoor seeding can be handled very nicely.

Covering the hotbeds with sash early enough to germinate weed seed is a big help in eliminating weed trouble in the seedbeds.

Rate and How to Plant.—There are usually about 65,000 seeds in an ounce and the number of plants produced depends a

great deal on the percentage of germination, but not every seed will make a good plant. It requires from 30,000 to 80,000 plants to set 1 acre, according to the planting distance used. One-fourth pound of seed per acre is usually planted by most growers for single-row planting.

One of the common mistakes made in sowing the seed in the hotbed is to sow it too thickly in the row, so that thinning is necessary. A rule-of-thumb method used to some extent is to plant 1 level teaspoonful of seed to each row in the standard 6-foot hotbed. Unless care is exercised in sowing the seed, the plants grow too thickly and do not form a stocky type. The rows in the hotbeds should be at least 3 inches apart and the seed covered to a depth of one-sixteenth of an inch.

Due to the small size of the seed and the slow rate of germination, soaking the seed 24 hours before planting will hasten germination and may decrease chances of loss due to damping off. Good stands were also secured where the seed was soaked until the white tips appeared before planting. For more even distribution, after soaking the seed may be mixed with some fine material such as fine sand. After it is sown and covered with soil, it may be covered with burlap sacks which will hold the moisture in the surface and prevent washing the seed out in watering. The germination of the seed is usually slow, even under favorable temperature and moisture conditions, and it requires from 6 to 8 days to sprout. After the seed has sprouted and is coming thru the soil, the burlap-sack covering should be removed and the beds provided with shade for a few days by covering with mats or laths.

As soon as the plants reach a height of about 3 inches, the tops may be clipped back so sunlight will hit the soil and keep the surface dry. This is of value in reducing damping off losses.

Hardening Plants.—Ventilation should be given daily, when weather conditions permit and increased gradually until the plants are able to stand up under outdoor conditions. In hardening celery plants it is better to withhold water and if temperatures under 50 degrees F. are used, they should not be resorted to longer than a week.

The plants should be watered, under ordinary conditions once a day, preferably the first thing in the morning, because the moisture on the plants then has an opportunity to dry off before night, and the plants will go thru the night in a comparatively dry condition. Watering during the hot part of the day or in the evening or at night is not recommended. Such a practice brings about a condition which is conducive to damping-off.

Premature Seed-Stalk Development

One of the problems which has caused a great deal of loss to celery growers in the state has been the premature development of seed stalks in the field. During some seasons as much as 40 percent of the total crop was unmarketable because of this condition. There has been considerable experimental work on this trouble and sufficient evidence produced to show the principal cause. Thompson* has shown that there is a direct relationship to the amount of damage by this condition and the date of sowing the seed in the hotbeds. Early plantings produce more seed stalks than late sowings and it was shown that it was better to plant as late as possible to produce the early crop wanted.

Further, there is a direct relationship between this trouble and the growing of plants under low-temperature conditions for 2 weeks or longer in the hotbed. If the plants are held at a temperature of 40 to 45 degrees F., the chilling they receive during that time is likely to hasten premature seed-stalk development. A good many growers believe that growth check, due to drying out of the plants in the seedbed before setting in the field, causes losses from this trouble. However, in this experimental work, drying in practically all cases reduced the number of seed stalks formed. Plants that were checked in growth, due to freezing temperatures, also delayed premature seed-stalk development. While a grower cannot control external weather conditions, it is believed that more attention should be given to planting dates so that losses from this cause may be reduced to a small percentage. Handling of the plants so that they will not be subject to low temperatures for periods long enough to produce seed stalks is another method of decreasing losses.

In case seed stalks do appear the only chance is to harvest and market the crop early, before the seed stalks are large enough to damage the quality enough to prevent sale.

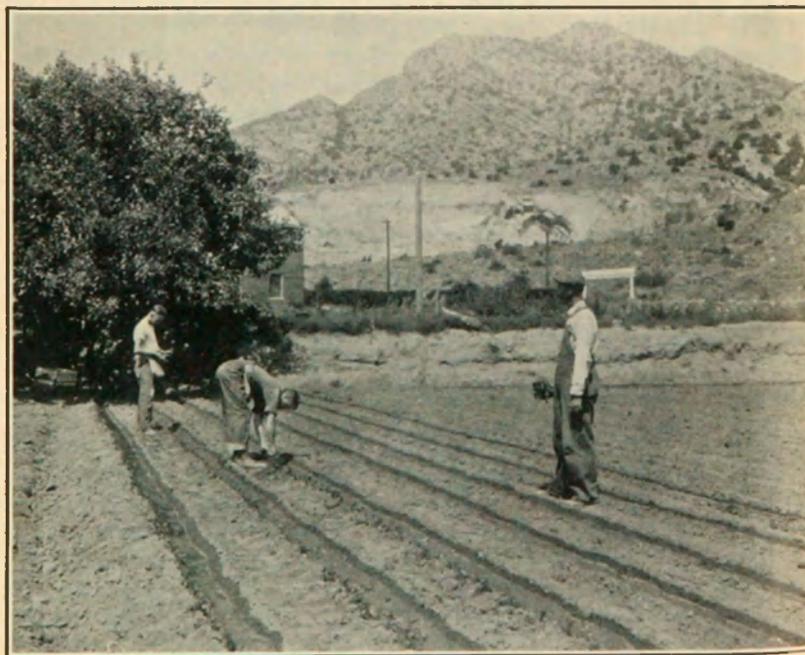
Setting Celery

Where celery is grown on commercial acreages and plenty of land is available, it is usually set in double rows 6 to 8 inches apart, 36 inches between the rows, and the plants 8 to 10 inches apart. In using this method, 30,000 or 43,000 plants are needed to set an acre. On the early celery, the double-row method is used to a considerable extent, while on the late celery there is usually a large acreage planted in single rows 30 to 36 inches

*Thompson, H. C. Premature Seeding of Celery. Bul. 480, Agr. Exp. Sta., Ithaca, N. Y.

apart. When the plants are set 6 inches apart in the row, from 34,484 to 29,040 plants are used to an acre. The number of plants required per acre varies widely, depending on the planting distances, the variety and the cultural and blanching methods used.

Practically all the celery is set by hand in Colorado, as the machine transplanters have not been used to any extent and there is some question as to their effectiveness under irrigated conditions. The rows are usually marked off at the proper distances with the irrigation shovel attachment on the cultivator. Irrigation water is usually run thru the furrows a day or two prior to field setting. As soon as the plants are set in a few rows in the field, irrigation water is again run thru the furrows and all setting is followed closely by irrigation. The plants must be set at the proper depth along the bank or edge of the furrow so that the heart of the plant is not covered. The soil must be firmed well around the roots to keep them from drying out rapidly, and the loose soil from washing away during irrigation. A dibble or a forefinger may be used for making an opening in the soil for the plant.



Transplanting celery. Notice the method used in irrigating before and after setting.

Cultivation

Frequent and shallow cultivation is desirable for growing celery as the root system grows near the surface of the soil. Often there is considerable trouble from weeds in the growing of celery, and cultivation should start as soon as possible after the plants are set and well started. This operation should start before the irrigation furrows dry out and bake around the plants. Knives or attachments can be used effectively in this cultivation, and will leave a ridge along the row which facilitates the first hoeing and it can be worked down at the same time. A fine surface mulch is exceptionally desirable and can only be maintained by constant clean cultivation during the growing season.

The small, horse-drawn cultivators can be used to advantage because there is but little soil thrown up on the plant and better surface mulch is secured. There is some acreage handled by using the small, hand cultivator. This method is especially advantageous when the plants are small, as the cultivation can be given close to the plants and weeding costs thereby reduced.

Irrigation of Celery

Celery is a crop which requires plenty of water all during the growing season. A good many growers follow the practice of irrigating before the first indication of wilting appears on the leaves, because it is thought that celery is greatly injured by wilting or any checking in growth. Where celery is planted in double rows, it is usually irrigated by running the water in between the double rows. The early celery is irrigated in this manner and the late celery is irrigated by a single furrow along the side of the row. There is no definite rule to follow in applying irrigation water, altho it is considered important to keep plenty of moisture in the soil thruout the season. Due to the wide range in the character of the soil, the slope of the land and the closeness to the water table, practically every grower applies water in different amounts.

The character of the subsoil is also an important factor in the application of water to the crop. While celery is a moisture-loving plant, if it is grown on soil which has a heavy, impervious subsoil, it will not make a good growth. While the crop requires plenty of moisture, it will not make a normal growth on highly alkaline soils or poorly drained soils. The matter of irrigation is of considerable importance in profitable production, in that over-irrigation favors the development of root rot and the growth of soft, succulent stalks. On the other hand, dry-grown celery has little quality, practically no crispness, and is of little

value on the market. The matter of irrigation is one which requires good judgment as to when to apply the water and how to use it intelligently. It is a good practice to favor any cultural practice which will conserve the soil moisture, and that will hold the moisture near the surface. It is also better to grow the crop on soils that have a high percentage of organic matter which will mean that there will be less loss of moisture by evaporation and that the number of irrigations can be reduced.

Blanching of Celery

There are usually three methods of blanching celery. First, paper; second, boarding-up; and third, banking with soil, all of which promote the development of flavor, crispness and tenderness in the stalks. The use of ethylene gas to blanch celery has not been used to any extent from a commercial standpoint. In using this method of blanching, the gas is released so that it will circulate around the celery in some air-tight compartment or room. The use of the gas has not been found satisfactory or economical under field conditions or so far where it has been used in refrigerator cars. The main objection to it is that it blanches the color out of the top of the leaves so that the celery has the appearance of being old. This detracts from its appearance on the market, and the heavy wilting of the plants is objectionable.

Several cooperative tests were conducted with shipping concerns on poorly blanched Pascal in the early fall, both in air-tight compartments and in refrigerator cars ready for shipment. The blanching was accomplished more satisfactorily in air-tight compartments than in a loaded refrigerator car. The gas is released at the rate of one part ethylene gas to 1,000 parts air in an air-tight compartment.

The late crop of celery is blanched by wrapping each plant with ordinary newspapers. These are folded at the proper width to meet the length of the celery stalk. The crop is blanched when it is about 10 to 15 inches in height. This method of blanching is considered to be quite expensive, yet it does a very satisfactory job of improving the color. The length of time for blanching by this method depends largely upon the rate of growth being made by the celery and the temperature during this period. Where paper is not used, boards 1 inch thick and 12 inches wide and about 16 feet long are placed by the side of the row to blanch the stalks. In using this method two men work, one on each side of the row, and place the boards along the base of the plants. They are held together at the base



Board blanching of early celery.

by the use of stakes driven into the soil or by wire hooks pushed into the soil. The top of the boards can be fastened together by nailing small lath strips across the top. The disadvantage of this method is the fact that it requires so much lumber.

The use of soil in blanching is not ordinarily used on the early crop, as the season in which it matures is usually warm and soil blanching favors the development of leaf spot and root rots. In using the soil method, it is necessary that the celery be planted in rows at least 3 to 4 feet apart. It is used more generally on the late celery crop and blanching may be started by working the soil toward the rows of celery by means of a celery hiller or banker. This pushes the soil up around the base of the plants.

Where the crop is to be blanched in winter storage, the process is started by using soil and the balance of the process completed during the storage period. It is possible as well to work the soil almost clear up to the top of the plants so that it can be held in the field 2 or 3 weeks longer. When it is banked high the crop can stand several light frosts without damage. The high banking of the soil is often practiced where the crop is to be marketed without storage.

In Colorado most of the late Pascal crop is blanched by wrapping individual plants with newspapers. This is done pre-

vious to placing celery in the winter storage trench. The wrapping is done on the late crop whenever the plants are of sufficient size and when it is removed to storage the newspapers are left



Paper blanching Giant Pascal celery near Welby.

on the individual plants. This method is apparently giving satisfactory results, since it protects the celery in the trench and produces the highest flavor as well.

The early crop or the Golden Self-Blanching variety is not artificially blanched but planted so that natural growth shuts out sufficient sunlight to promote blanching.

Harvesting

The early celery crop, as it is grown in this state, is usually marketed immediately after the stalks have been properly blanched and are of proper size. The celery plants are loosened from the soil by either a hand spade, which can be used to cut under the plant, or by a horse-drawn cutter. Care should be taken not to cut too far ahead of the trimmers, as the stalks will readily when exposed to wind and sun. As a rule, the celery plant is cut 1 to 2 inches below the base of the leaves, and the plants are then removed and trimmed.

Where the crop is grown on a small scale and each individual plant wrapped separately, there is more choice in selecting the individuals that are well blanched. On the other hand, where a horse-drawn cutter is used all plants of different sizes and in

different stages of blanching are removed and more loss is experienced in the field. After the celery is cut, the plants are lifted, the earth shaken from the roots, and the old, outer, rough leaves removed before packing in crates. If too many of the roots have been left on the plants, they are removed by trimming with large knives. In case the celery is to be blanched in storage, the old outer leaves are left on the plant and the brown or decayed portions of the leaves and stalks are trimmed off. Where the plants are to be stored directly in the earth trench, there are usually more roots left and these are placed in new soil in the bottom of the trench and very little trimming is necessary.

The size of crates used varies according to the variety of celery grown, the growth made and the market. These factors all determine the method used in packing the crate. However, as a rule, 6 to 10 dozen make a crate of the early celery, while 4 to 6 dozen make up a crate of the late Pascal celery. The early celery crop is seldom, if ever, placed in storage. It is usually marketed immediately, whereas the late or Giant Pascal variety is generally placed in storage for a period of 2 to 3 months. The packing and trimming of the late crop is usually done by removing the celery from the trench and hauling it to the packing sheds, where it is properly trimmed, washed and tied in bunches of 12 before being packed in the crates.

Preparation for Market

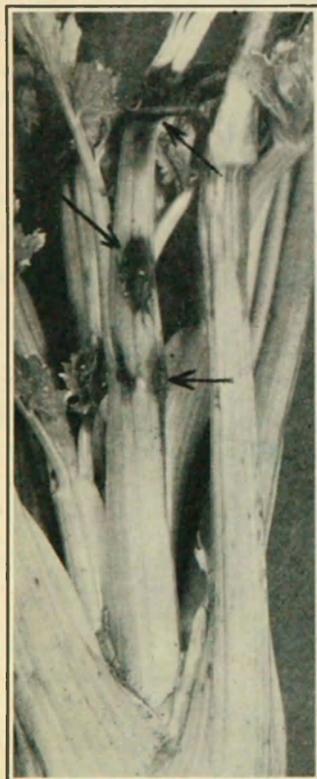
The celery stalks should be trimmed of all outer, rough leaves, and thoroly washed before being tied in bunches. The distance to market determines, to a certain extent, the amount of trimming necessary for the celery to carry well. If the market is local, the trimming can be done much closer than if the crop is to be shipped in carload lots to distant markets. Many growers are so equipped that they can wash and bunch immediately before hauling to the local market.

The trimming is usually done by means of small knives and the bunches tied by hand. In a few instances growers have used a small bunching machine for tying, but as a general thing such equipment is used only on a limited scale.

Ordinarily, the celery stalks are wrapped in bunches of a dozen. The number of stalks in a bundle is determined by the size of the celery, the variety, and the local or market demand. Some growers have found it profitable to tie the celery four stalks to the bundle to meet the requirements of the small family.

Celery Diseases*

Damping-Off Disease (*Pythium debaryanum*).—This disease is the most serious trouble in the seedbed, which causes the celery plants to rot off at the surface of the soil. The disease itself is caused by a soil fungus, and is most likely to appear during periods of moist, damp weather. It is also more apt to do damage the first 2 weeks after the seedlings have appeared thru the soil. Where the plants are grown in hotbeds, coldframes, or greenhouses, it is important to water carefully and ventilate regularly so that conditions are unfavorable for the development of the fungus. A thin layer of sand sprinkled over the surface of the soil in the seedbed will be of value in reducing losses. It is much better to water the plants in the morning so that they



Late blight opens the way for other storage rots, after the celery has been stored in the trench for a short time.

can dry before night. Irrigation during dark, cloudy days tends to promote the disease. Regular ventilation, careful watering, allowing plenty of light for the plants and keeping the seedbed slightly dry will be of value in preventing the disease. Planting the seed too thickly in the hotbed, and allowing the plants to grow in a very crowded condition favors damping off.

Late Blight of Celery (*Septoria apii*).—This disease which is caused by a fungus is one of the most destructive diseases on celery in Colorado. It usually is first noticed about the middle of July and appears as small, circular, yellow or brown spots on the leaves and stems. In the center of these spots are developed small, black, fruiting bodies which may be produced on either side of the leaf. From these bodies large numbers of spores are produced that can be scattered by wind, rain or carried by tools and man to other plants in the field. In heavily infected fields the leaves turn brown and die. When plants are placed in storage the diseased

*The material on celery diseases was corrected and additional information furnished by E. W. Bodine, Assistant in Botany, Colorado Agricultural Experiment Station.

spots open a way for other rots which cause serious losses. This disease is favored by moisture and moderate temperature.

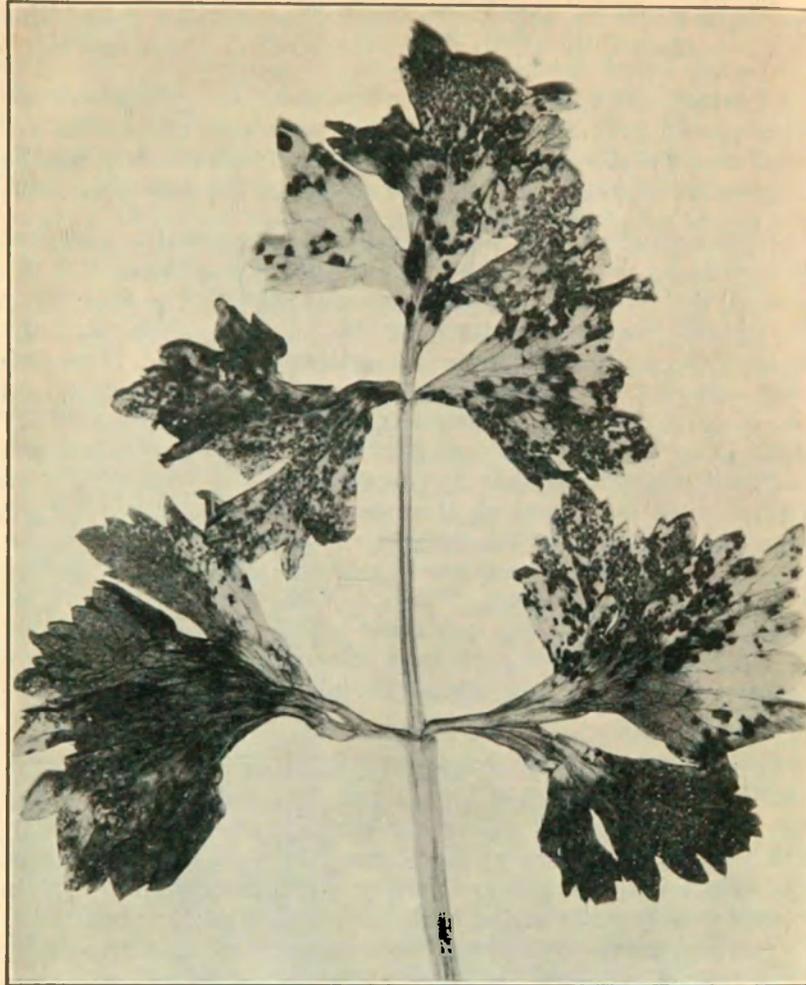
Control.—The disease is more prevalent on fields where celery is grown year after year without proper rotation. The removal of old stalks, leaves and trimmings from the field will be of value in reducing sources of infection for the following year.

Effective control of the disease was secured by spraying with bordeaux mixture. The seedlings were sprayed twice in the seedbed, with a standard 4-4-50 bordeaux spray. The first spray was applied when the plants were about 2 inches high, and the second spray put on shortly before setting in the field. More frequent spraying may be necessary in the seedbeds; however, on control experiments two sprays in the seedbed were generally sufficient for control. The field spraying should begin as soon as the plants are well started. Four applications of 5-5-50 bordeaux mixture gave good control. However, more spraying may be necessary in wet, growing seasons. Check plots were left unsprayed thruout the season, and there was a marked difference in the growth of the plants. The spraying tests showed that the disease can be effectively controlled when sprays are properly applied. It is important to start spraying early, as once the disease spreads to any great extent, control is very difficult.

Copper-lime dust, 20-80 or 15-85, has been very successful in other states in controlling late blight. The amount of dust per acre depends upon the size of the plants; when dusting half-grown plants, 35 pounds per acre should be used. This should be applied when air currents are moving slowly and when the leaves are wet with dew. Spraying or dusting should be done before the disease appears in the field as it affords a protection during rainy periods, at which time the late blight disease is scattered and grows into the host.

Early Blight (*Cercospora apii*).—The early blight leaf-spot is also a fungus disease, and can be distinguished from late blight by the ash-gray color of the spots on the leaves. It usually starts in June and is most destructive in July and August. It usually starts on the margins of the leaves, and the spots also unite to form irregular patches. The same spraying as was recommended for late blight will also be effective in the control of early blight.

Yellows (*Fusarium* species).—This disease has become very prevalent in the Golden Self-Blanching variety of celery in the



Late blight of Giant Pascal celery. The numerous black spots (Pycnidia) are characteristic of late blight.

Val Verde district near Denver, and has been likewise spreading to the Giant Pascal variety. The causal organism occurs in the soil and it is common where celery is grown year after year on the same soil. The plants so affected become light yellow in color, are checked in growth, the roots and crowns decay, and the plants finally die in the field.

During the past few years, strain tests have been made of selections of yellows-resistant varieties secured from the Michigan Agricultural Experiment Station. These tests on resistant

varieties have been conducted periodically since 1925, but the varieties were not suitable for market use. During the summer of 1933, the Colorado Agricultural Experiment Station, Botany Section, obtained a strain called Michigan Golden which proved to be highly resistant to yellows on heavily infected soil in the Val Verde district near Denver. This strain, however, is not resistant to other diseases, and protective dusts and sprays must be used to prevent leaf blights. For information concerning sources of this seed, write to the Colorado Experiment Station.

Celery Insect Pests*

During the past 2 years shipments of celery carrying excessive poison residue have been subject to seizure. The federal tolerance regulations for 1934, as announced by the United States Department of Agriculture, are as follows:

Not to exceed .01 grains of arsenic trioxide per pound of edible produce.

Not to exceed .01 grains of fluorine per pound of edible produce.

Not to exceed .019 grains of lead per pound of edible produce.

Growers may best comply with these regulations by avoiding the use of the poisons listed above, as the crop approaches marketable age. At all times during the growing season these poisons should be applied very moderately.

Pyrethrum, derris and hellebore are three insecticides that have been considered as non-poisonous to humans, and their use is recommended when spray must be applied shortly before the crop goes to market.

Only a few of the more common pests and their controls can be mentioned here. Further information may be obtained by writing to the Colorado Experiment Station, Entomology Division, at Fort Collins.

Cutworms.—Early injury characterized by plants being cut off near surface of soil. July and August injury caused by worms feeding on stalks and shoots above ground, usually in central portion of plant.

Control.—Scatter poisoned-bran mash just before dark;

*Material on celery insect pests was furnished by S. C. McCampbell, Entomology Division, Colorado Agricultural Experiment Station.

cutworms are night feeders. Early season injury controlled by scattering poisoned bait over ground. For July and August injury, poisoned bait must be thrown into crowns of the plants.

Formula for Poisoned Bait

Paris green	1 pound
Bran free of shorts.....	25 pounds
Molasses	1/2 gallon
Water	2 to 3 gallons

Caution.—Paris green contains arsenic and should be scattered very lightly; only a very small particle is required to kill a cutworm. It is not safe to use this bait as harvest approaches unless washing is sufficiently thoro to remove all poison residue.

Webworms.—Both alfalfa and sugar-beet webworms attack celery. Arsenical sprays must not be applied too heavily, even early in the season, and as the crop approaches marketable size pyrethrum or derris products should be used. Usually injury occurs in June and may be controlled by moderate applications of calcium arsenate at the rate of 3 pounds to 100 gallons of water.

Red Spider (Mites).—Cause leaves to blanch and become white. Attack generally in small areas at first, and spread over the field. May be avoided by dusting with a mixture of 3 pounds of dusting sulphur and 1 pound of hydrated lime.

Aphids or Plant Lice.—Spray with the following mixture; 1 pint of 40 percent nicotine sulphate, 4 pounds of laundry or fish-oil soap, 100 gallons of water, or dust with mixture of 1 pound of 40 percent nicotine-sulphate and 9 pounds of hydrated lime.

False Chinch Bug and Tarnished Plant Bug.—Injury caused by bugs sucking juice from plants. Difficult to control. Avoid infestation by cleaning up trash and weeds around fields. Spray or dust with double strength of spray or dust mixtures recommended for aphids. Heavy applications of dusting sulphur may give protection.

Preparation of Celery for Winter Storage

There are many factors which determine the keeping qualities of celery in the winter-storage trench, and the most important are as follows:

1.—The stage of maturity of the plant at the time of trenching. Plants should not be too old or too immature, but just the right stage to trench. Control planting and field-setting dates to get this stage of growth.

2.—Plants placed in the storage trench must be free from disease, especially late blight. This fungus develops and opens the way for other rots, which work down from the leaves to the stalks in the storage trench. This is the main reason why growers must control late blight during the growing season.

3.—Do not store celery that has been frosted. This opens the way for rots in the trench, and the break-down of the entire plant follows very rapidly. Start harvesting early in the fall.

4.—Discard all plants for winter storage that have been crushed, have broken stalks, or otherwise damaged in handling during the harvesting. Here again such tissue opens the way for storage rots.

In preparing celery for winter storage, most of the plants are wrapped individually with newspapers, and placed in the trench with the paper on each plant. However, if the above-mentioned points are observed, the rot loss in storage can be reduced to a minimum. Carefully discarding such plants will complete the preparation for trenching.

Winter Storage of Celery*

During the winters of 1926 and 1927, a number of types of celery storage were tried; cellar storage, cement-pit storage, pits lined with planks and ordinary earth trenches. It is not advisable to go into a detailed description of construction of these different types of storage structures, but to give a summary of the results obtained.

The cellar storage consisted of a structure most of which was below the ground, with shingled roof, and which was partially insulated. A ventilating system was provided both from the door and from the end opposite the door, giving a good circulation of air upon the floor. The celery was stored in the fall in moist sand.

The cement pits were made wholly below the ground, 14 to 16 inches wide and 20 inches deep. The thickness of the cement wall was between 4 and 5 inches. The bottom consisted of garden soil which had been spaded up so as to permit the setting of the plants in the soil.

The storage with wooden sides was made in the same manner as the cement storage, the only difference being that in place of cement, wooden planks were used. The bottom of the trench was the same as that for the cement pit.

*The portion on winter storage of celery was written by Dr. E. P. Sandsten, Director of the Colorado Experiment Station.

Earthen storage pits were trenches 20 inches deep and the same width. The soil was of such character that the walls stood up without caving. The celery used for the storage was grown in a nearby field and transferred directly to the storage structure at harvest time.

The first year's trials indicated very plainly that the earth-trench method was not only the most economical but gave the best results. The cellar storage was the poorest, followed by the cement, the trench with wooden sides being next.

Careful Handling Necessary.—Believing that the manner of handling the celery plants at the time of harvest had a great bearing upon the keeping of the celery in storage, care was taken to prevent bruising, so that only whole and healthy plants were stored. To compare these carefully handled plants with the ordinary method of handling, a portion of the crop was handled in the usual manner. The result, so far as the storage structure was concerned, was the same as the year before, but there was a difference amounting to 15 to 20 percent in favor of the plants handled carefully at the time of storage.

The conclusion drawn from this experiment shows plainly that it is not only the question of storage structure, but also the manner of handling the plants preparatory to storing that controls success. The grower should exercise the greatest care and eliminate the torn, bruised and diseased plants, or parts of plants, before they are placed in the storage structure. The earthen trench, if properly constructed and if healthy plants are placed in storage, will give the best results, besides being the most economical. New pits can be constructed right in the field where the celery is grown, thus eliminating the cost of hauling and extra handling in bringing it to storage if located some distance away from the field.

Care must be taken in digging the plants so that each plant will have as many of the roots intact as possible. The plants should be free of excessive moisture and in a normal state of dryness. The soil in the bottom of the trench should be moist but not wet, and the plants should be set firmly in the soil and the soil packed around the roots. The trench should always be of sufficient depth so that the top of the plants will be 1 to 2 inches below the top level of the trench. Provision should be made to water the soil so as to keep it moist thruout the storage period, but no water should be applied to the leaves or the stalks of the celery. A tile at the end of the trench and a gentle slope to the trench will enable the application of moisture thru the tile down to the floor of the trench without wetting the plants.



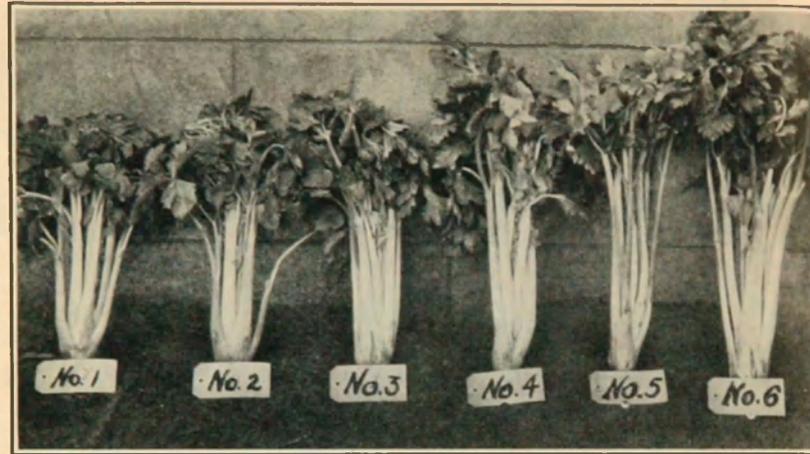
Winter storage trench for celery.

The best and most convenient method for covering the trenches when cold weather sets in is to place boards over them. Then cover with straw, hay or cornstalks. The covering should be increased with colder weather. Care must be taken not to permit moisture to get thru and wet the plants. There is sufficient moisture from the soil and the sides to keep the plants from wilting, and extra moisture will result in losses from decay.

In some seasons, one may succeed by using dry straw as a covering directly over the celery plants, but if heavy rains should occur the water will wet the straw, and breakage and damage of plants, followed by disease, will inevitably occur. The trench method will enable the grower to keep his celery for Christmas and the January trade, and it should be in prime condition.

Celery Varieties

There are not as many celery varieties listed in seed catalogs as there are other vegetable crops. Four or five varieties make up the list that is used on a large commercial basis. In Colorado there is more acreage planted to the late Giant Pascal variety than to the early self-blanching types. The Dwarf Golden Self-Blanching variety is being replaced to a considerable extent by the tall Golden Self-Blanching type. The New Golden Detroit variety, resembles the Golden Self-Blanching and is mentioned for a trial.



Early varieties of celery: 1. Golden Self-Blanching (Dwarf) 2. Golden Self-Blanching (Dwarf). 3. Golden Plume. 4. Golden Self-Blanching (Tall). 5. White Plume. 6. Golden Self-Blanching (Tall).

Golden Self-Blanching (Dwarf).—This variety is used for the early crop, and for shipping purposes. It is early maturing, stalks are prominently ribbed, color is yellowish-green, and it is short and compact in growth. It blanches to a very nice creamy-yellow color, and holds up well when shipped. The quality is not good, but its blanched appearance is in its favor.

Golden Self-Blanching (Tall).—This newer type is an improvement over the Dwarf Golden Self-Blanching. The stalks are longer and more inclined toward pithiness but the quality is better. Other characteristics are similar. However, it does not stand long-distance shipping as well as the dwarf type. It is not easy to grow good, stocky, vigorous plants of this variety, as it seems to be slow in starting and more care is necessary in the seedbed.

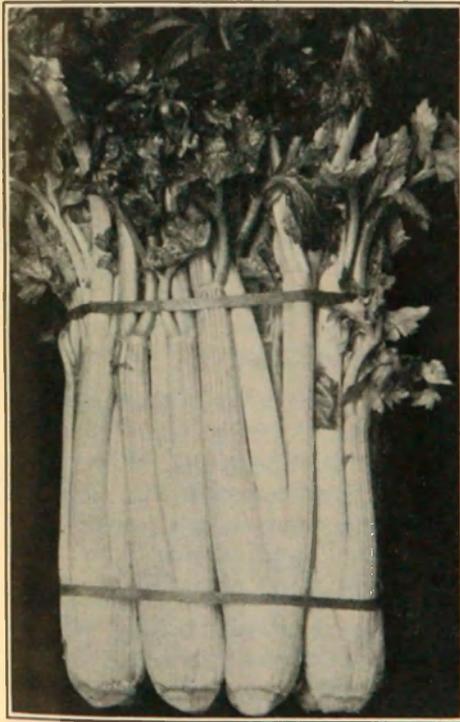
Easy Blanching.—This is a newer variety resembling Golden Self-Blanching in size and growth habit, altho it is later in maturing. The stalks are greener in color and are more difficult to blanch. The quality is not good. It is not used commercially in Colorado, but is of value for the home garden. It is a good keeper.

Golden Plume.—An early, tall-stalk variety similar to the Golden Self-Blanching. It blanches easily to a golden-yellow color. The stalks will not stand up satisfactorily for long-distance shipping. It is a desirable variety for home gardens or local markets, and its quality is fair.

There are several strains of the Golden Plume variety such as Wonderful and Meisch Special, but they are not grown to any extent in Colorado.

Table III.—Early Celery Variety Trial

Variety	Average Weight Per Stalk	Percentage Pithy	Percentage Culls	Total Percentage Unmarketable	Average Height of Stalk, Inches
Golden Plume	1.1	30.0	7.5	37.5	9.84
Tall Golden Self-Blanching	.81	0.0	11.8	11.8	11.50
Dwarf Self-Blanching	.67	.9	10.8	11.7	8.20



Giant Pascal celery.

The tall Golden Self-Blanching variety was the superior one for local markets, because of its long well-blanching stalks with good weight and appearance. In looking over the table it must be understood that the results are given for comparative relationship only, since there is always considerable difference between different strains and seed stocks. Seed purchased from different seed sources produces results which vary, especially in connection with the percentage of pithy and cull plants. The difference in length of stalk on different varieties is of comparative value.

The Giant Pascal.—A late-maturing, winter type grown extensively in Colorado. The growth is vigorous, compact and erect. It is a heavy yielder; the stalks are thick, round edged, and nearly smooth ribbed; it blanches slowly to a creamy-white color; the quality is excellent; it has a fine nutty flavor when properly blanched. This type keeps well in winter storage. Many fine

strains have been developed by growers in Colorado, which vary in length of stalk, blanching characteristics, and keeping qualities. Home-grown strains show some resistance to late blight.

Giant Pascal Strains.—A table of the results of strain trials is given to emphasize the variation that occurs in different strains of Pascal and to point out the importance of knowing the seed source before buying seed.

Table IV.—Giant Pascal Strain Trials

Seed Source Index No.	Percentage Pithy	Percentage Culls	Average* Height Stalk, Inches	Average Weight Per Stalk, (Lbs.)
1	0	4.0	12.8	1.06
2	0	5.0	10.9	.88
3	0	1.0	12.4	.76
4	0	0.0	11.3	.68
5	0	3.6	12.0	1.06
6	21.5	1.5	13.1	1.20
7	0	2.4	11.9	.96
8	0	3.5	13.3	1.00

*Length of stalk from base to first leaf.

There is considerable difference in weight, average height of stalk, and in the percentage of culls (unmarketable). One strain is high in percentage of pithy plants.

Growing Pascal Celery Seed

Giant-Pascal-celery growers in Colorado have produced seed for their own planting for many years. No attempt has been made to grow seed in large commercial quantities. When more seed is produced than is necessary for their own use, they sell the excess to other growers or to seedsmen. It has proved to be a profitable practice, and many fine Pascal strains have been selected and developed by celery growers in Colorado.

Where experienced and reliable growers carefully selected the plants for seed production, a much superior strain has been developed. Some shippers, however, are of the opinion that some Pascal strains have been selected for too high a quality and have lost some of the shipping characteristics necessary for long-distance hauls. The ribbing of the stalks is less distinct than in the old type of Pascal and the stalks are much longer. Pithy stalks, sprouting crowns, and the tendency to shoot to premature seedstalks has been reduced to a minimum. Resistance to late blight has been increased to some extent as well. Some strains grow rapidly in winter-storage trenches so that they are ready

for the Thanksgiving market. Others develop much more slowly and hold well for the late December markets. Since there is considerable interest among inexperienced growers in growing Pascal seed, a brief outline of the methods used is presented.

Selection of Mother Plants for Seed.—Experience is necessary in selecting plants for seed production. Growers usually have a particular ideal in mind in making these selections, and save only those plants which come up to a certain standard. Some prefer a long-stalk type and others the shorter-stalk plant. The difference depends largely on the demands of the market. In making selections it is necessary to observe carefully the length of the stalk and the leaf characteristics. The ribbing of the stalk should be indistinct, the stalks thick, not flat and thin, and they should have well-filled, round edges. Save only vigorous, sound, healthy plants for seed increase. There are a few points that can be used to eliminate entirely a plant for seed selection. They are as follows:

1.—Do not save a plant with pithy or hollow stalks. Eliminate any which have outer pithy stalks and solid central stalks.

2.—Do not select a plant with a tendency to produce sprout crowns or one that develops numerous small hearts around the crown.

3.—Discard plants which have the mosaic disease which is characterized by a mottled dark and light-green leaf color.

4.—Do not save plants for seed which have light-yellow leaves. The difference may be due to a variety mixture. Discard plants of darker-green leaf color than is standard for the variety.

5.—Do not save plants from strains that show a tendency to produce premature seedstalks.

Pithiness.—Pithiness is a condition in celery in which the stalks of the plant are hollow. It has been attributed to growth checks, poorly selected seed, and to rapid growth following a growth check. Where the crop was severely stunted in late summer by the drying out of the soil and then heavy amounts of irrigation water applied, pithiness has been said to develop.

Severe injury by late blight and by webworm-feeding has also been said to increase the tendency to form pithy plants. The evidence of Sandsten and White¹ and Austin and White² has

¹ Sandsten, E. P. and White, T. H. An inquiry as to the cause of pithiness in celery. Md. Bulletin 83, 1902.

² Austin, C. F. and White, T. H. Second report on the cause of pithiness in celery. Md. Bul. 93, 1904.

shown that pithiness however, is largely inherited. That is, seed collected from pithy mother plants produced a high percentage of pithy plants. Therefore the trouble can be reduced to a large extent by careful selection of plants free from pithiness for seed production.

Emsweller* in working with the type of pithiness which affects the entire plant, presents evidence to indicate that it is hereditary. He recognizes two distinct types of pithiness; one in which the entire plant is pithy even when very young; and another type in which the outer petioles become pithy while blanching.

Winter Storage of Celery for Seed.—There are three methods used in Colorado to carry over selected mother plants during the winter, which are as follows: First, winter-storage trench; second, coldframes; third, outdoor cellars.

The storage trench used for carrying seed plants thru the winter is the same as previously described for commercial celery, but the roots are completely covered with soil, and more covering must be provided over the trench to protect the plants from freezing. The advantage of this method is that additional information may be secured on the keeping quality of the selection during storage; the rate of growth may be observed in the trench, and the blanching characteristics of the seed plants recorded. Seed plants which do not keep well, grow too slowly, sprout badly around the crown, and that do not come up to standard in all respects may be discarded entirely. After these characteristics have been observed, the plants may be removed from the trench, excess stalks trimmed off to the heart, and the crowns placed in a cool frost-proof cellar under moist sand until ready to field-set. A large number of plants may be carried thru the winter by this method and the big advantage in using it is the additional information secured on the winter storage characteristics of the selections.

A few growers carry Pascal seed plants thru the winter by selecting desirable plants before frost in the fall, trimming the stalks from the plants and setting the crowns in the soil in a coldframe. Protection against frost is provided by mats and straw manure covering. The plants can be reset in the field in early spring before much growth has started or they may be permitted to produce seed in the coldframes as set.

There are a few growers who select the seed plants late in the fall, trim them to the crown, and store in a cool frost-proof

*S. L. Emsweller, Amer. Soc. of Hort. Sci. Vol. 23, Page 480, 1932.

cellar during the winter. The crowns are covered with moist sand and set out in the field in early spring for seed production.

The time to set plants varies in different parts of the state. In the southern part this can be done as early as February, while in sections with the shorter growing seasons, there is danger of killing frosts until April. By covering the crowns with several inches of soil, April plantings are satisfactory. Seed plants should be set in a well-drained, light, loam soil that is in a high state of fertility.

The planting distance used varies, however, a $3\frac{1}{2}$ to 4-foot row will permit later cultivation, and a spacing of 18 to 24 inches between plants will allow plenty of space for the development of seedstalks.

Harvesting the Seed.—The most important point in harvesting celery seed is to cut the stalks at the right stage of maturity. The seed matures somewhat unevenly, and the only indicator of maturity that can be used is the change in color from light green to light brown. When a large percentage of the seed is brown, the seedstalk can be cut. The seed shatters easily, and care must be taken in cutting the seedstalk. This is accomplished by hand methods. High winds and rain favor heavy shattering, and the seed must be observed carefully so that it can be cut at the right time with very little loss.

The seedstalks are then placed on canvas in the field to dry out. In case of rainy or unfavorable weather at that time, it can be dried under open sheds. The seedstalks can be crushed by hand flailing and the coarse stalks removed with a rake. The seed is cleaned by running thru a fanning mill, and is then spread out on a canvas to complete the drying process before final sacking for storage. Celery seed will hold high germinative quality for several years under cool, dry, well-ventilated storage conditions.

Maintaining Selection and Increase Plots.—Some growers are not careful enough, or do not have the time necessary to select and grow seed with good selection back of their stock. There are only a few who have specialized in growing high-quality seed. In order to do this, it is necessary to have experience in selecting the finest plants available, store them away from the commercial celery, and plant in a location where there can be no cross pollination with other celery varieties.

The most effective means of improving selections is to save seed from individual plants separately, and number each one.

The seed from each plant should be planted separately under the mother-plant number in a test plot. Records and observations on the yield and the general performance of each mother-plant line should be made and only those that prove to be the most desirable held for increase in seed production. All the undesirable lines should be discarded. It is highly important that only the finest plants be saved for seed production since carelessness in selection may result in a high percentage of pithy individuals or unmarketable culls appearing in the seed increase.

Isolation of Seed-Increase Plants.—Isolate or set the mother-seed plants where they cannot be cross pollinated with another variety, with plants of undesirable characteristics, or with celeriac.