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SWEET POTATO PRODUCTION IN CALIFORNIA

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FOREWORD

The sweet potato is one of the leading truck crops of the United States, but at the present time it is only of minor importance in California. In 1922, the year of heaviest production, there was grown in the United States 1,117,000 acres of sweet potatoes, producing 109,394,000 bushels. The crop provided approximately 55 pounds of sweet potatoes per capita for the entire population of the United States. In the same year the acreage of sweet potatoes in the states west of the Rocky Mountains was: California 8000, Arizona 2000 and New Mexico 1000, a total of 11,000 acres, producing 1,292,000 bushels. Therefore, for the seven and one-half million people living in the eight states west of the Rockies, there was produced in this district only about 10 pounds of sweet potatoes per capita. This small production in the western states as compared with that of the country as a whole has resulted in a low per capita consumption of sweet potatoes and their shipment from the southern and middle western states to the Pacific coast markets. Thus, in 1923, Los Angeles received 41 cars of sweet potatoes from Californian points, 35 cars from Arkansas, and 9 cars from other states. The sweet potatoes supplied to western markets are often rather poor in quality and inadequate for the market demands. The retail price, moreover, is too high to encourage large consumption, except during that brief portion of the year when the crop is being harvested and most growers are hurrying their product to market.

On the other hand, returns to the grower have not always been satisfactory because much of the crop is sold during the temporary

over-supply of the markets at digging time in the fall. The 1922 crop was an example of such a condition. Prices during the fall were so low that the crop of some fields was not dug at all—yet by the following February the wholesale price had risen to 5 cents a pound for the properly cured storage house product. Adequate storage facilities would make it possible to market at more satisfactory prices many more sweet potatoes than are now grown in California. Adequate storage facilities would tend to eliminate such uneconomical practices as shipping sweet potatoes from Arkansas, Tennessee, and other distant regions, to Pacific coast markets. The usual seasonal variation in prices of sweet potatoes is indicated by figures 1 and 2.

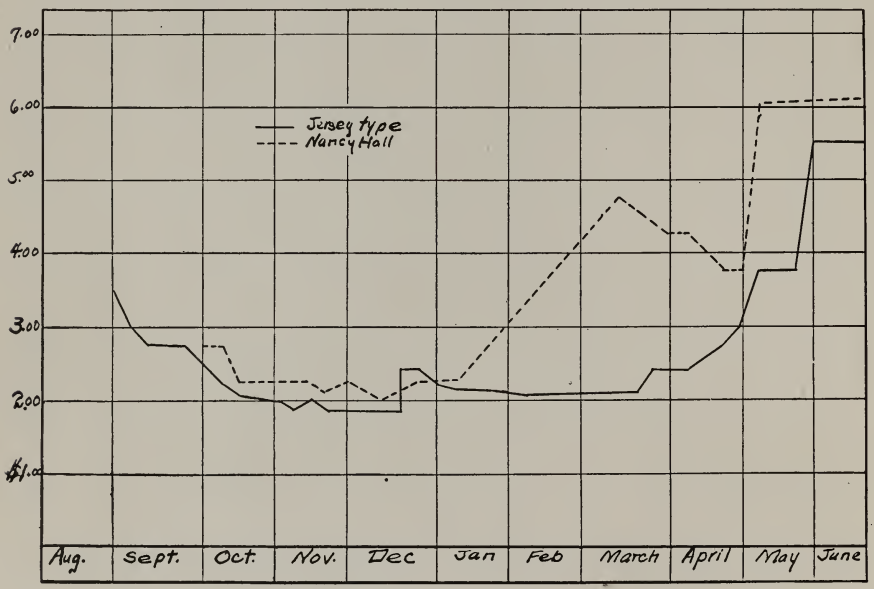

Fig. 1.—Seasonal range in jobbing prices on Jersey and Nancy Hall sweet potatoes at San Francisco, 1922–1923.

Factors that must be considered if yields, production, demand and consumption of sweet potatoes are to be increased, are disease control, and the production of varieties or types that are more popular with the consumer. Two diseases commonly known as stem rot and black rot in many cases are destroying 10 to 50 per cent of the crop. Both are controllable to a large extent by well proven methods. Varieties of the sweet, moist-fleshed type, such as Nancy Hall and Porto Rico Yam, are not only more productive and better for storage than the dry mealy Jersey type now so generally grown, but are preferred by many consumers.

It is the purpose of this circular to give such information regarding sweet potatoes as is available and applicable to California conditions, and as is thought necessary to increase the yield and the market demand.

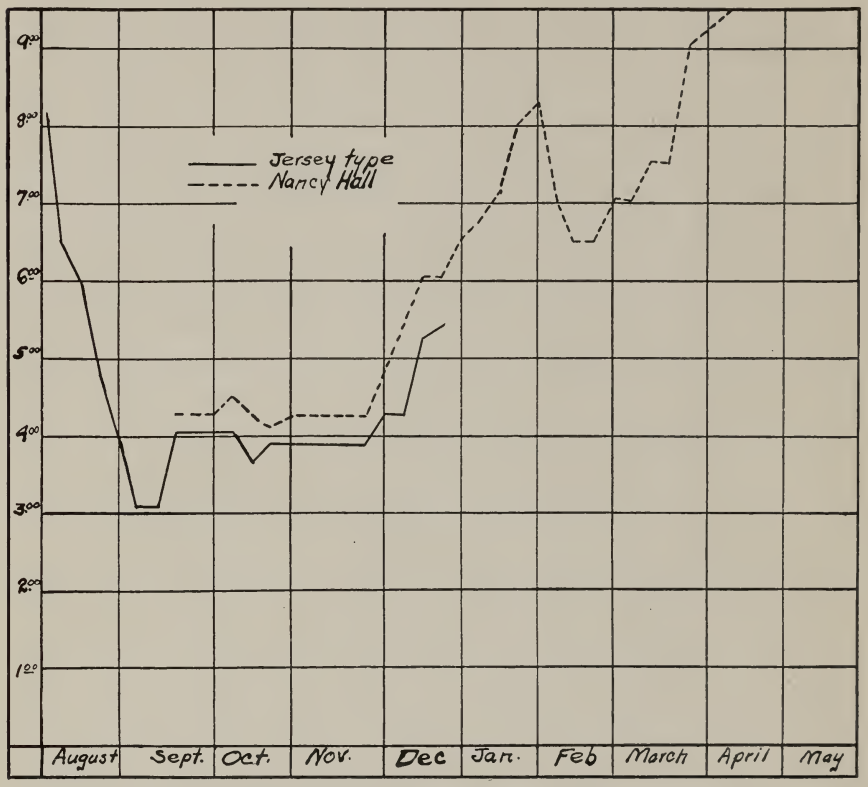

Fig. 2.—Seasonal range, jobbing prices on sweet potatoes, San Francisco, 1923–1924.

REQUIREMENTS FOR GROWING SWEET POTATOES

Soils.—Areas for commercial sweet potato production are limited by the special soil requirements for growing this crop, especially under irrigated conditions. Generally, light sandy loam and coarse sandy soils are most suitable. Fresno Sand and Oakley Sand are the soil types most used for sweet potatoes. The fertility necessary as compared with that required by other crops is not very high. Yet some of the sandy soils on which sweet potatoes are now grown, would probably produce larger crops if organic matter and commercial fertilizers were added. The physical texture of the soil seems to

affect both the form, size, and smoothness of the potatoes. On the heavier soils, the top growth is likely to be so excessive as to retard maturity and cause inconvenience in digging. One advantage of sandy soils is that they retain less of the irrigating water than do heavy soils. The plants grown on sandy soils, therefore, suffer less from excessive moisture. There is a considerable range in the soil adaptation of different varieties. The Jersey type, especially, requires sandy soils, while the Nancy Hall, Porto Rico, and some of the large white varieties will develop satisfactorily on medium-heavy loam soils.

Climate.—The sweet potato requires a long warm growing season. The plants are very sensitive to frost and therefore cannot be set in the open field until danger of frost is over. Since the tops are also killed by the first heavy frost in the fall, the crop should be dug before or soon after the first frost. The normal development of the plant is retarded by cool cloudy weather during the growing season, and regions having cold nights during the summer are not favorable. Hence, sweet potatoes are grown in California only at some distance from the coast, except south of Los Angeles.

Moisture.—While the sweet potato plant probably uses as much water as any other crop having the same amount of foliage and grown under the same conditions, the fact remains that the plant is not injured seriously by rather long periods of drought. This has led to the idea that sweet potatoes are a drought-resistant crop. Excellent crops have been grown in the Turlock district, on sandy land, without irrigation, but such soils are usually sub-irrigated to some extent from nearby canals. Good growth and yields have been observed where by mid-summer there was no available soil moisture nearer than 20 inches to 2 feet from the surface. On higher lands which are not sub-irrigated, regular surface irrigation by the furrow method is practiced.

SWEET POTATO DISTRICTS

The larger portion of the sweet potato acreage of California is located in Merced and Stanislaus counties in the extensive area of sandy soils adjoining the main line of the Southern Pacific railway. Both soil and climate are very favorable for maximum yields of sweet potatoes of good quality. Smaller sweet potato districts are located in Los Angeles County, in the San Fernando and San Gabriel valleys, and in Orange and San Diego counties. Sweet potatoes have also been grown successfully in the upper part of the Sacramento Valley, at Redding; in Kern County, at Bakersfield and Shafter; in southwest Fresno County, and to a small extent in the Imperial Valley near Yuma.

GROWING THE PLANTS

Sweet potatoes are usually propagated by means of plants produced from small potatoes placed in a hotbed, with proper moisture and temperature conditions. The sweet potato itself consists of a root, originally a fibrous feeding root, which in process of development has thickened for a greater or less distance from the central stem. On each such thickened root, or potato, are found four rows of lateral fibrous feeding roots, which usually disappear before the crop matures, so that only the slight depressions where these roots were attached can be seen. From the neighborhood of these root scars, adventitious buds originate, and under favorable growing conditions, sprouts are formed. These sprouts have an independent root system and are only weakly connected with the mother potato, from which, however, they derive most of their food up to transplanting time. The sweet potato root has no true rest period, for the sprouts may start growing at any time moisture and temperature conditions are suitable. This often occurs in the storage house in the early part of the storage season, also in the field before harvest, when the partly developed roots are separated from the main stem by diseases.

The potatoes used for propagating are called "seed" or "seed stock." The smaller potatoes ranging from one to two inches in diameter are most suitable for this purpose. Larger potatoes may be used, but they are more expensive and do not produce so many plants from a given quantity of seed stock. Where it is necessary to use large potatoes, the yield of plants can be increased by splitting the potatoes lengthwise, and bedding with the flat side down. The selection of sweet potato seed is discussed in detail at the end of this circular. Growers in the Turlock district allow about 400 pounds of seed for each acre to be planted. From 10,000 to 14,000 plants to the acre are required, depending on the distance of planting. If there is no disease, the seed disinfected, the hotbed properly prepared and carefully handled, 200 pounds of seed should produce enough plants for one acre.

Preparation of the Hotbed.—The bed for growing sweet potato plants is usually heated with fresh stable manure. It should be located in a warm, sunny, well-drained spot, and protected from north winds, by a fence or windbreak. A trench is dug 6 to 8 feet wide and 15 inches deep, and as long as necessary to accommodate the quantity of seed to be bedded. When plants for a large acreage are grown, it is best to arrange the plant beds in short sections parallel to each other. Several days before the sweet potatoes are bedded, the trench should

be filled with fresh heating horse manure which is first packed by tramping, then covered with a layer of 3 to 4 inches of sandy soil or sand. On this the seed potatoes are laid about one-half inch apart, when the bed has become warm. The seed should be covered at once to a depth of three inches. The best material for covering is clean sand, preferably taken from a creek bed or sand pit where contamination by sweet potato diseases is unlikely. As the plants or "sprouts" can obtain all the necessary nutriment for their development from the mother seed potato, there is no need for a fertile soil

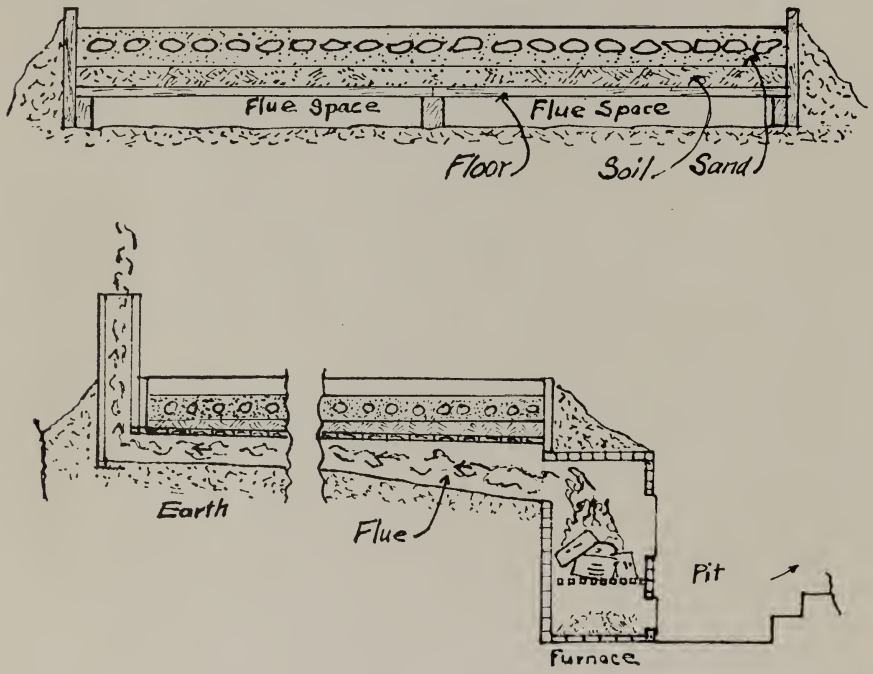

Fig. 3.—Fire-heated hotbed. Above is shown cross-section of the bed. The flue-space extends the entire width and length of the bed and is covered with rough flooring. Over this is a layer of tamped soil or clay from 3 to 6 inches deep, above which is the sand in which the potatoes are bedded.

Below is shown a side-section, showing arrangement of furnace and flue.

in the plant bed. Furthermore, sand does not bake and crust in such a way as to prevent the sprouts emerging, as heavier soils often do. Also the formation of fibrous roots on the plants is much more extensive when grown in sand, than in heavier soils. The last is an important factor, especially with varieties such as the Nancy Hall, which form fibrous roots sparingly and are therefore more difficult to transplant successfully. Plants grown in sand are also pulled up more easily and with less damage to the root system. Another advantage of using

clean sand in the preparation of the sweet potato plant bed is the avoidance of diseases, especially black rot and stem rot, which are likely to be harbored in soils taken from the cultivated fields, or which have been used for sweet potato beds in previous years.

Other Types of Hotbeds.—Because of the increasing difficulty of obtaining sufficient quantities of fresh stable manure for the preparation of large plant beds each year, other methods of heating the beds may have to be resorted to. The flue-heated bed, one type of which is shown in fig. 3, is well suited for growing sweet potato plants. A pit

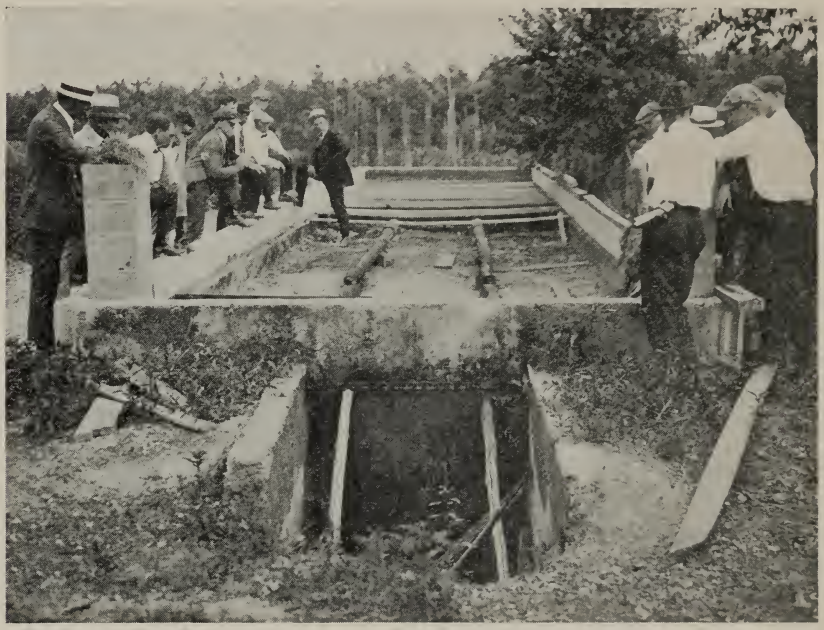

Fig. 4.—Top view of fire-heated hotbed, concrete construction. (Courtesy New Jersey Experiment Station.)

is located at one end of the bed. Recessed beneath the bed, and opening into this pit, is a brick furnace, which may be equipped with a grate for burning coal or briquettes. The smoke, fumes, and heat from the firebox are conducted beneath the plant bed, either through tile flues spaced 3 feet apart and entering a chimney at the far end through a header; or the hotbed may have a tight floor, with an open space beneath, extending for its entire width and length and connected with a chimney at the far end. Heaters of either of the above types may accommodate beds 8 to 12 feet wide and 40 feet long. For larger beds, it may be more economical to use coils of pipe for steam or hot water heating.

In the cooler sections, sweet potato beds are enclosed by a frame of 1 by 12 inch boards and covered with glazed sash or medium weight unbleached muslin cloth, water-proofed by treatment with hot raw linseed oil. In the warmer sections, including the Turlock district and the lower San Joaquin Valley, the beds are seldom enclosed, but are covered with board shutters 3 to 4 feet wide and slightly longer than the bed is wide. These shutters are placed on the surface of the beds at bedding time, to retain the heat in the bed. After the bed has once warmed up, there is danger of over-heating, and the shutters are removed from time to time to regulate the temperature. When the plants begin to push through, the shutters are permanently removed. A thermometer should be placed near the center of the hotbed, and the temperature kept around 80° F. until the sprouts have started.

SEED TREATMENT

One of the most important steps in the control of sweet potato diseases is disinfection of the seed potatoes before bedding. This is especially important in the control of black rot, both in the hotbed and after transplanting to the field. It is also helpful in controlling other diseases. It should be remembered that seed treatment is only one step in the control of sweet potato diseases, and will not be very effective unless the other precautions for disease prevention—seed selection, clean hotbed soils, and rotation of crops—are also observed. Seed treatment is intended to destroy the disease organisms on the surface of apparently sound healthy seed. Under the influence of the warmth and moisture of the hotbed these organisms grow and attack the young sprouts. Many of the plants are often killed in this way in the hotbed before transplanting, and many others are infected and die later in the field, reducing the stand, and lessening the yield.

The standard method of disinfecting seed sweet potatoes is by dipping the seed for 10 minutes in a solution made up at the rate of one ounce of corrosive sublimate (Bichloride of mercury or Mercuric chloride) to 8 gallons of water. The corrosive sublimate should be dissolved beforehand in a gallon of hot water, to which may be added one pound of common table or bulk salt to hasten the process. Fairly rapid solution can be obtained even in cold water with this mixture of the corrosive sublimate and table salt.

It is usually convenient to dip lots of from 60 to 75 pounds of seed at a time, using a 50- or 60-gallon wooden barrel containing 32 gallons of the solution. Dipping the seed for longer than 10 minutes is likely to cause injury.

As the corrosive sublimate reacts quickly with any sort of metal, the solution should be prepared and handled only in wooden, stoneware, glass or enameled containers. As it is also deadly poison to all animal life the powder and the solution must be kept out of reach of children and stock.

The solution of corrosive sublimate is weakened by dipping the seed potatoes. Gunny sacks should not be used for containers in dipping the seed because the jute fibre from which they are made absorbs large amounts of the chemical from the solution. Wooden baskets or cotton sacks may be used, or the seed may be dumped into the solution loose. The last is the best practice if the barrel or dipping vat is located on an elevated platform, and is provided with a large drain plug so that the solution can be promptly drained off into another barrel at the end of each treatment.

To keep the solution up to the original strength, a small amount of corrosive sublimate should be added occasionally. It has been found by experiments that the addition of one-half ounce for every 100 pounds of seed treated, together with enough water to restore the original volume, will keep the strength of the solution about constant. If the solution is used over four times without addition of more corrosive sublimate it becomes so weak that the treatment is not effective. If a stock solution of 4 ounces to the gallon has been prepared, one pint of this should be added for every 100 pounds of seed dipped.

The seed potatoes, upon removal from the solution, should be allowed to drain a minute or two, then placed directly in the hotbed, without rinsing.

TRANSPLANTING

The transplanting of the plants from the hotbed to the field should begin as soon as danger of frost is over, and the preparation of the hotbed should consequently be timed so that the first crop of plants is ready for transplanting about the time the weather becomes warm enough for field setting. In the Los Angeles district, transplanting usually begins about April 1 and continues until the first part of June. In the San Joaquin Valley, transplanting begins the latter part of April and continues until late in June. Objections to late planting are that it is difficult to secure a good stand because of the heat, and that the shorter growing season reduces the yield. It is the general experience of growers in California that the earlier transplantings produce the larger crop. Some experiments in Kern County, conducted by W. B. Camp in 1923, strikingly demonstrate the decrease in yield from late plantings. The test included Southern Queen, Nancy

Hall, Dooley, Porto Rico, and Big Stem Jersey, the results with all being similar to those given below for the Jersey variety.

Date Transplanted	*Results—Dug October 27*
May 21	Good yield. Large uniform potatoes, nearly all marketable.
June 9	Fair yield, many medium size potatoes, 30 per cent small.
June 25	Light yield, nearly all small potatoes.
July 11	Light yield, all small potatoes.

In pulling the plants for transplanting, the mother or "seed potato" is held in place with one hand and the plants are pulled up with the other. Plants more than 10 inches high should be pruned by cutting off the tops of the bundles of plants with a large knife. After pulling, the plants should be kept out of the sun until transplanted. The roots especially should be kept from drying out. Sweet potato plants may be held for several days after pulling or may be shipped long distances, if the roots are kept slightly moist, by wrapping in moistened newspaper. The tops must be kept dry, otherwise slimy decay takes place within a day or two.

Most of the commercial acreage of sweet potatoes is set with horse-drawn transplanting machines, of which there are several types on the market. These machines are equipped with a tank and an automatic device which discharges a small amount of water at the roots of each plant as it is set. Even though the soil seems moist at transplanting time, it is best to use the watering attachment. On very sandy soils, which dry out quickly, and when transplanting late in spring, it is best to give a row irrigation within a day or two to moisten the ridges and give the young plants a favorable start before they have become dry.

Propagation by Vine Cuttings.—In the southern states it is customary to grow a late crop from vine cuttings or "slips" taken from the tops of the early crop, which is always grown from plants propagated in hotbeds. The cuttings of the sweet potato take root readily when severed from the parent plant and transplanted to a new location under favorable conditions. Roots form very quickly from the nodes. The cuttings may be from 10 to 30 inches long, but the shorter cuttings are much more conveniently handled when transplanted by machine. Propagation by cuttings does not seem to be generally advisable in California because of the difficulty of getting a stand in mid-summer, and the small yield produced by late plantings. Propagating in this way, however, may be desirable for one reason: namely, the production of potatoes free from disease especially for seed purposes. One of the worst diseases, stem rot, is spread from year to year within the seed potatoes. The disease works within the stem of the

plant, from the root upward. However, cuttings taken from the tips of vines that appear to be healthy, early in the season, are very likely to be free of disease, and if transplanted to a field where the soil is also free from sweet potato diseases will produce healthy potatoes. This method then results in production of seed that is nearly disease-free, and may be expected to produce healthy plants if bedded under proper conditions the next spring. "Slip seed" grown on nematode-free soil is also the only way to make certain of nematode-free seed.

This practice is known in the South as "slip seeding" and is of importance in controlling disease, if other precautions are also observed. A very satisfactory crop of seed was grown at Delhi, California, in 1924, by this method.

CULTURAL PRACTICES

The exact details of culture for sweet potatoes vary in different localities. A few general suggestions, however, may be useful to the prospective grower who has had no experience with this crop.

Sweet potatoes are nearly always planted on ridges from 8 to 15 inches high, the lower ridges being generally preferred. Ridge-culture provides more favorable conditions for the development of the roots, facilitates row irrigation and reduces the labor of harvesting as compared to flat culture. The rows are generally marked off 3 feet apart, and the ridges formed with a lister. The riding disc cultivator can also be used to form ridges after removing all but the two inner discs and setting these at the proper angle to form a ridge between them. The tops of the ridges are smoothed slightly with a plank drag before setting plants, if a transplanting machine is used.

The spacing of plants in the row should be varied to suit conditions. Varieties that tend to make excessively large potatoes, especially the Nancy Hall, should be set much closer than varieties that tend to produce a larger number of medium-sized potatoes, such as the various strains of the Jersey type. On the more fertile soils all varieties should be spaced closer than on poorer soils. The average distance between plants in the row is 15 inches. This may be shortened to 10 inches, or lengthened to 18 inches, according to the variety and soil fertility.

When the young plants begin to send out runners, it is necessary to turn these so that they will grow along the ridge and not interfere with cultivation between the rows. This vine turning is usually performed by hand, but some of the growers equip their cultivators with rods to lift the vines out of the way. If the tips of the vines are covered with soil during cultivation they are likely to take root and

form small potatoes which detract from the development of the potatoes in the main hill. Eventually the vines cover the space between the rows and cultivation is discontinued, though irrigation may be continued as late as September 1 on late plantings.

Most of the sweet potatoes in California have hitherto been grown on sub-irrigated land in the Stanislaus-Merced district with the water table 4 to 5 feet below the surface during the growing season. With the lining of the canals to prevent seepage and the pumping being carried on in some districts to lower the water table, it will probably become necessary to resort to surface irrigation. The crop can be grown very successfully with surface irrigation (by the furrow method) but the cost is greater than under sub-irrigated conditions. Where sweet potatoes are to be surface-irrigated, the land should be carefully graded and the water handled so as to get as even a distribution as possible. During the dry season of 1924 many fields received emergency irrigations and it was found that in those portions of the fields where too much water was received the potatoes were over-sized and rough, and many of them cracked.

Even more important is the relation of soil moisture to disease. During 1924, the portions of the fields that were rather dry or that received only a moderate amount of water were fairly free from the black rot disease. In the lower and excessively moist portions of the fields a very large proportion of the potatoes were affected with black rot. Careful and uniform distributions of water will do much to lessen the losses caused by this disease.

On sub-irrigated land two surface irrigations are usually given shortly after transplanting. On the higher lands, about seven irrigations during the growing season are required.

HARVESTING

The time of harvesting depends on market conditions and the maturity of the crop. Sweet potatoes planted out in May will continue growing until the tops are frosted in November. The rate of growth of the potatoes themselves has not been determined for California conditions, but the increase in yield for the last few weeks of growth is probably not very great at least for early planted potatoes. On the other hand, there is a period in the middle of the season when the increase in size of the potatoes is very rapid.

Harvesting begins in August in central California, and slightly earlier in southern California. The first sweet potatoes from Imperial Valley, reach market about July 15. Even the earliest plantings are

not nearly full grown when harvesting begins, but the high price received for the earliest potatoes compensates for the smaller yield. Harvesting increases in volume through September and October. Practically all of the sweet potatoes dug before the middle of October are sold on local markets or shipped at once. Those intended for storage are harvested from the middle of October until after the tops have been frosted. The effect of the freezing of the tops on the quality of the roots is a much disputed question, though it is generally believed that unless the tops are cut off the day after the first killing frost the

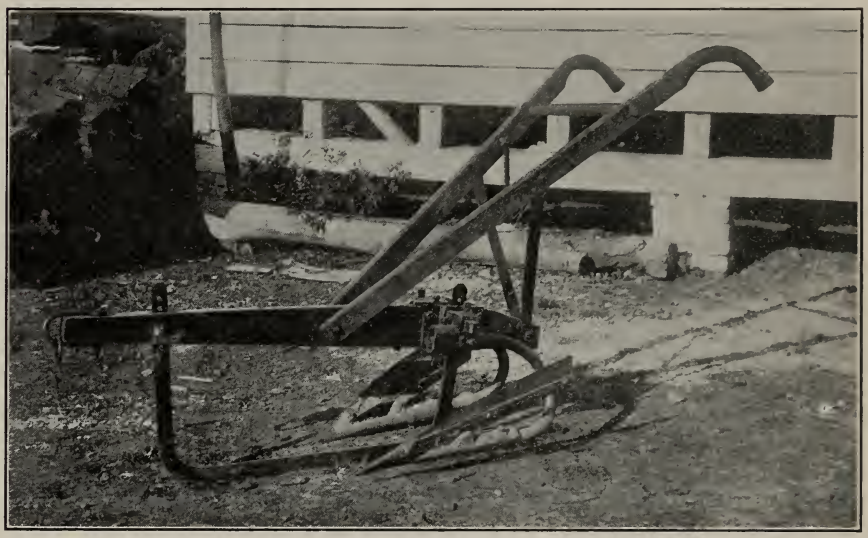

Fig. 5.—Vine cutter, drawn by one horse, used in stripping sweet potato vines in Virginia. (Courtesy Virignia Truck Experiment Station.)

potatoes will not keep well in storage. Certainly the effect of temperature low enough to freeze the tips of the potatoes themselves, either before or after digging, is disastrous.

In harvesting, the first step is to dispose of the tops. Most of the California growers now do this by hand, using long curved knives to cut them from the central stem. They are then removed and piled in convenient places to be used later in covering the heaps of potatoes. Recently the value of the tops as stock feed has been realized, and many of them are taken from the fields by the dairymen for feeding to their cattle. The tops may also be clipped from the main stem with a hoe, and left between the rows so that they will be buried in plowing out the potatoes. In some eastern districts the slow laborious task of cutting the tops by hand is avoided by the use of a horse-drawn "vine cutter," such as that shown in fig. 5.

After the tops are cut and removed from the ridges, the roots are plowed out. A 14-inch mold-board plow may be used for this purpose. Most growers, however, have plows with specially adapted mold-boards for this work. One grower, Mr. J. B. Steele of Baldwin Park, California, has adapted an old Irish potato digger for harvesting sweet potatoes, by removing the elevator apron and welding on an extra wide and heavy point. The ordinary potato digger has not proved successful with sweet potatoes because of the large amount of power required and the excessive bruising of the potatoes. After plowing out, the crop should be gathered promptly. In the San Joaquin Valley the practice is to leave the potatoes attached to the central stem and gather the crop into large piles at convenient intervals through the field. These piles are covered with sweet potato tops to protect them from the sun and from light frosts that are likely to occur late in the fall. As a rule, the potatoes are sorted from the piles and packed in shipping crates the day they are dug. This practice is probably the most convenient and economical where the potatoes are being dug for immediate shipment. However, the covered piles may be left in the field for several days. The over-sized, the cracked, the small or seed-sized, the stringy potatoes and the stem are left on the ground to be gathered up later. This practice makes it impossible to select healthy seed—a thing that is best done in the field at the time of digging. When the potatoes have been snapped from the stems, it is impossible to tell which have come from healthy plants, and which from diseased plants. The safest plan is to inspect the individual hills immediately after plowing out, choosing those which show potatoes of desirable type, and which prove to be healthy upon splitting the central stem. The smaller sized potatoes, still attached to the stem, may then be gathered and saved for seed purposes. A few careful growers have been successful in selecting healthy seed from the piles, however, by inspecting the stem of each intact hill and laying aside the "seed-size" potatoes at the time the No. 1 potatoes are packed.

In harvesting sweet potatoes it is essential to avoid all rough handling that tends to bruise them. The skin is very tender when the potatoes are dug, and it is easily broken or rubbed off. Where the flesh is exposed in this way, the molds that cause rotting are likely to gain entrance and even if rot does not occur, a sunken discolored spot is caused that injures the appearance. All unnecessary handling should be avoided especially for potatoes that are to go into storage. Storage stock should be placed in lug boxes without piling, hauled directly to the storage house, and emptied into storage bins at once.

PACKING

For many years, the standard container for California-grown sweet potatoes was the 100-pound crate. Experience has shown, however, that this is too large and heavy for the best results in shipping, and in recent years most of the crop has been packed in "Special" or "three-quarter" crates which hold 75 to 80 pounds as packed in the field. The inside dimensions of this crate are 9¾ by 14 by 22½ inches. In packing the crate is first nearly filled and then a top layer of uniform-sized potatoes is carefully arranged so as to give a good bulge to the cover when nailed on. The pressure from this bulge holds the potatoes firm, thus preventing movement in the crate, and lessening the injury to the appearance of the potatoes in a slack pack.

The U. S. Standard Grade for No. 1 sweet potatoes calls for potatoes not less than 1½ inches and not over 3½ inches in diameter. These size requirements are rather carefully observed by California growers. The over-sized "Jumbo" potatoes as well as the cracked, cut, or otherwise imperfect potatoes are usually not marketable, except as stock feed. It is estimated that when barley is worth $50 a ton, sweet potatoes are worth $15 as feed for dairy cattle. The sizes below No. 1 grade are utilized for canner stock and for seed. For canning, long potatoes from ¾ to 1½ inches in diameter are demanded. Somewhat smaller potatoes serve as well or better for seed. The "strings" also have some value as feed for hogs.

VARIETIES

Of the many varieties of sweet potatoes grown in the United States, only a few are important in California. From the marketing standpoint, this is fortunate, for when a district specializes on one or two varieties of a crop it is easier to put out a standardized product and to build up an established reputation for it. Still, the leading varieties differ enough in their adaptability to different soils and localities, suitability for market purposes and other characteristics, to justify the grower in considering carefully the varietal question. Below are discussed some of the main points connected with varieties now grown or likely to be grown in California.

The Jersey Type.—There are several distinct strains of this general type, which together comprise most of the commercial acreage. One strain has been grown in this state for many years, and is generally spoken of as the *"Old California."* It appears to be distinct from any of the Eastern strains. The potatoes are long and slender, there

are a large number to the plant, and under unfavorable growing conditions many of them do not reach sufficient thickness for the market grade. Generally, this strain produces a larger proportion of canner and seed stock than any other variety or strain grown. Its vines are rather slender with small leaves of variable type, some being narrow and pointed, some distinctly forked or three-lobed, and others broadly triangular. Another strain, grown extensively in recent years, is generally referred to as the *"New Jersey"* strain, seed having been imported from that state about 1921. This is the same as the Eastern variety, Little Stem, or Up River. It can scarcely be distinguished from the California strain by the appearance of the leaves or runners; the potatoes, however, are much shorter and thicker, more chunky or short-spindle shaped than the California. This strain has become very popular, as it produces a large yield with a high percentage of No. 1 potatoes. A third strain is the *Red Jersey,* quite similar to the New Jersey strain in every respect except the intense red color of the skin. It has no special qualities to commend it and is not in demand on the markets.

The Jersey strains in general produce well on very sandy soil, but perhaps are the least adapted of all varieties, to the heavier soils. This type of sweet potato has a dry mealy flesh, which is preferred by some people. At present it is the most popular variety for summer and fall use on the Pacific coast markets, but generally sells at a lower price than other varieties during the winter. The various strains of this type are rather early in maturing. The small light growth of top and the fact that potatoes adhere to the central stem more strongly than other varieties, are advantages in harvesting. In storage-quality, the Jersey type is decidedly inferior to other varieties even under the best conditions, the potatoes usually beginning to shrivel at the stem end about a month after being placed in storage. This defect in the Jersey type is more noticeable in California than in the East. Because of its poor keeping quality and the market preference for other sorts in winter, it is not advisable to store the Jersey type in commercial quantities for more than a few weeks.

Nancy Hall.—This variety has recently been grown in California in commercial quantities and is justly increasing in favor. The potatoes are medium-long, spindle-shaped, tapering at both ends, smooth and uniform when grown under favorable conditions. The skin is light pink of uneven density. The flesh is pink while raw, becoming golden yellow and very sweet and juicy when cooked. Many prefer this type when they once become acquainted with it. Varieties like the Nancy Hall having moist sweet flesh are often spoken of as "Yams" though

the true Yam is a tropical plant belonging to another botanical family, and is not grown in the United States. The Nancy Hall is early and very productive. It is one of the best keeping varieties, and therefore well suited for storage. While best adapted to the sandy soils, this variety thrives well enough on moderately heavy soils to make a satisfactory crop for home use. On account of the rapid early growth of the potatoes and of their tendency to grow too large, this variety can be dug for the extra early crop when only half grown, yet produce satisfactory yields. Objections to this variety are: its tendency to grow potatoes that are too large or rough; susceptibility to Stem Rot disease; and difficulty in obtaining a good stand of plants in the field, on account of small number of roots formed by the sprouts before transplanting from the hotbed. The tendency to over-sized roots can be corrected by setting the plants close in the row. Spacing the plants as close as 6 inches in the row has been found to give maximum yields on moist fertile soils.

Porto Rico.—This variety is of somewhat the same general type as the Nancy Hall, but is considered superior in some respects. The potatoes are of a deep coppery red and have a deep pink flesh, which is richly colored and very sweet and juicy when cooked. The potatoes are rather irregular, though most of them are spindle-shaped, and of medium length. This variety has been very successfully grown in the Los Angeles district for several years and in 1924 several small patches grown at Turlock and Delhi proved its adaptability to the San Joaquin Valley. Though this variety is practically unknown on the markets of northern California and the Northwestern states, its fine qualities will soon render it popular in these sections. It is not particularly early, but is well suited for the main fall shipping crop and for winter storage.

Southern Queen.—This is a large coarse-growing variety, having white skin and cream-colored flesh. Though not in demand on the markets, because of the white color, it is of fairly good eating quality after it has been in storage for several months. This variety is hardly grown at all in California. It is known in the Turlock district as the "Tennessee."

STORAGE

The sweet potato is commonly regarded as a difficult crop to store over winter, because of its sensitiveness to cold and susceptibility to rots caused by fungi when the storage conditions are defective. However, during the past ten years very satisfactory and dependable methods for sweet potato storage have been worked out, largely by the U. S. Department of Agriculture, and thousands of the modern storage

houses have been erected in the southern and eastern states. California growers have been very slow to provide suitable storage facilities for sweet potatoes. There is only one large storage house and two small houses of more or less modern type in the state. On account of the mild climate, California growers have been fairly successful in storing sweet potatoes in cellars in some years. However, conditions in these cellars are seldom well regulated and the losses by decay and shrinkage are generally very heavy, a total loss being a common occurrence in cold or wet seasons. The inferior quality of cellar stock as compared to "cured," or the storage house stock, is reflected in the much lower prices paid for the former. Data from the San Francisco market reports bear out this statement.

The great advantage of storing sweet potatoes is that it greatly extends the marketing season and the period for consuming the crop. Instead of forcing the entire crop onto the market during the digging season, from August to November, a large part may be held in storage for marketing during the winter and early spring. Sweet potatoes can easily be kept as late as May 1. Thus the length of the sweet potato season may be doubled. Unlike many vegetables, sweet potato consumption is not seasonal. If available, they are used as extensively in winter as in autumn. Development of more and better storage facilities will provide an outlet for much larger crops of sweet potatoes than have ever been grown in California.

The sweet potato requires a warm, dry, well ventilated storage place if it is to be kept through the winter with minimum loss from shrinkage and decay. An important factor is a preliminary "curing" or sweating process, given for the first 10 to 14 days after the potatoes go into storage. During this period the temperature should be held at 80° to 85° F., and the ventilators kept open so that excess moisture can pass off from the potatoes freely. Some chemical changes occur in the potatoes themselves during this curing process: the skins become tougher and thicker, and the cut and bruised places seal over so that rot-producing fungi cannot gain entrance. After curing, the storage rooms should be held at 50° to 55° F., with the ventilators opened or closed according to temperature and moisture conditions outdoors. The necessary conditions for curing and holding sweet potatoes through the winter can best be supplied in specially constructed sweet potato houses. These houses do not have to be so substantially constructed in California as they do in eastern states, and need not be expensive. Persons interested in commercial storage of sweet potatoes are advised to secure Farmers' Bulletin No. 970 from the U. S. Department of Agriculture, Washington, D. C.

Fig. 6.—Showing dead plants and missing places in sweet potato field, just before harvest. Due to black rot, chiefly.

Fig. 7.—Healthy field of sweet potatoes with practically no missing places. Seed were carefully selected and dipped in Corrosive Sublimate solution. Nancy Hall variety on left, Jerseys on right. A. R. Vierra, Turlock, California.

DISEASES

The sweet potato is subject to several destructive diseases, affecting both the plant and the potato, and to some diseases which attack the potato only. These diseases have been increasing in severity in recent years. Some of them are prevalent at the present time, and are the cause of great loss to the growers who often are not aware of them. The control of disease is the chief problem now confronting California growers, from the standpoint of production.

During the summer of 1923 and 1924 many fields in the main sweet potato districts were visited by the writer. In most cases some disease was present, and in some fields 40 to 50 per cent of the plants were dead or dying of disease. There can be little profit with such a large reduction in the stand. It costs as much to plant, cultivate, and irrigate a field with only half a stand of plants as with a full stand. Losses of plants of only 10 or 15 per cent, which may not even be noticed by the grower, will reduce the yield in nearly the same ratio, which in years of low prices may entirely prevent all profit. Losses of plants just after transplanting are often attributed by growers to causes other than disease, while death of plants during the growing season often passes unnoticed. The chief diseases are so widely spread and may cause such heavy losses that the simple specific measures for preventing them should always be followed, whether or not the growers know them to be present.

The two diseases which cause most loss in California, commonly known as stem rot and black rot, are prevalent in other parts of the country also, and their control has been carefully worked out. Fortunately, investigations carried out in 1923 and 1924 by Dr. J. L. Weimar of the U. S. Department of Agriculture, in coöperation with the Farm Advisors of Stanislaus, Merced, Los Angeles, and Orange counties, demonstrated that the same control measures that have proved so effective in the eastern states will also control these diseases in California. The chief diseases are briefly described below and on the last page is given a summary of the methods of control.

Black Rot.—This disease is caused by a fungus which attacks the underground part of the stem as well as the potatoes. Decayed spots of varying size appear upon the potatoes. These spots are black on the surface and somewhat sunken. The decay often starts in growth cracks or in places wounded by gophers; while in storage, cuts and bruises are the chief starting points. The decay is not very deep and if cut away the sound flesh below turns a greenish color soon after

Fig. 8.—Selecting seed from cull-pile in the field. The wrong way to get healthy seed.

Fig. 9.—The right way to select seed sweet potatoes. The hills are laid out and stem of each one is examined for disease.

exposure to air. The flesh just below the decayed spots is very bitter and when potatoes affected with black rot are cooked the bitterness permeates the whole potato. This disease is often found on seed stock in the spring as black patches on the sides, or as a dry, shriveled and blackened condition at the stem end of the potato. On the plant, infection by Black Rot may be first noted at the time the plants are pulled in the hotbed for transplanting. At this stage the stem is black and decayed for a short distance from its basal end. Such plants die soon if transplanted to the field, although sometimes when conditions are not favorable for the development of the disease, they may grow and produce several potatoes which are likely to be diseased. Many plants

Fig. 10.—Black rot on sweet potato, showing surface decay. (U.S.D.A.)

that do not show infection when pulled for transplanting may really be infected and die after transplanting. Infected plants which do not die in the early part of the season, may be recognized at harvest time by the dry black decay of the lower part of the central stem. Such plants usually produce only a few small potatoes.

The black rot fungus attacks no plant but sweet potatoes, yet it may survive in the soil over winter and even for several years. Rotation of crops is therefore a necessity as a part of any method of control. But if the soil is free from disease to begin with and all the other measures to prevent infection are observed, several crops of sweet potatoes may be grown in succession on the same land. The most important cause of infection is the use of infected seed. If potatoes showing black rot are bedded in the plant bed, the fungus grows from the mother potato and attacks the new plants. Even seed potatoes that appear to be healthy, generally have a plentiful supply of the fungus on their surface, if they have been stored in bins with

infected potatoes. However, healthy plants may be grown from seed of this kind if it is disinfected before bedding according to the directions given on page 8, and bedded in a disease-free hotbed. The seed potatoes that have visible signs of Black Rot should be sorted out at bedding time and destroyed as they cannot be disinfected.

Another source of infection is the soil of the plant bed. On many farms there is only one spot that is sunny, sheltered from wind and accessible to water. The tendency is to make the sweet potato plant bed in this one favored spot year after year. When plant pulling is

Fig. 11.—Black rot on sweet potato plants, upon removal from hotbed. (U.S.D.A.)

finished in the spring, the old beds are left without further attention until bedding time the next spring. By this time the soil in and around the beds is likely to be saturated with the fungous organisms that cause black rot and other diseases, which have spread from the decaying seed potatoes of the previous year. In fact, many growers prefer to make their plant beds on the same spot as in previous years because of the improvement in physical texture of the soil through the incorporation of the decayed seed, plants and manure of previous years. The result is a plant bed soil thoroughly infected with diseases which infects each new crop of plants in turn. There are three remedies for this situation. One is to make the plant beds in a fresh spot each year—but this is not always possible. Another is to sterilize the soil

before preparing the plant bed each spring. Drenching the soil with a solution of formaldehyde (one pint to 30 gallons of water) at the rate of one gallon to each square foot of surface would probably disinfect old hotbed soils so that they could be used again. Generally, however, the most practical method is to make the plant bed with fresh soil or sand hauled from a place where contamination by sweet potato disease is not likely, such as a dry creek bed. With a layer of this soil or sand 3 or 4 inches deep below the seed potatoes, and a covering of the same material, the chances of infection reaching the plants from without are slight.

Stem Rot.—This disease, like black rot, is caused by a fungus that may live in the soil for several years. It attacks both the potatoes and the stems, but differs from black rot in that it develops entirely within the tissues, being seldom visible from the exterior until the plant dies. Potatoes borne by diseased plants usually contain the disease, and as they are likely to be small and therefore used for seed purposes, they are one of the chief causes of the spread of the disease from year to year. In advanced stages, potatoes affected with stem rot show a blackened ring just below the skin, but so many in less advanced stages do not show this ring that healthy seed cannot be secured by discarding those that do not show this discoloration. The only way to secure absolutely healthy seed is to select them from healthy plants at digging time. Each hill should be inspected by splitting the central stem. If the interior is brownish in color, the plant is infected with stem rot, and the potatoes it bears are not suitable for seed. This disease also occurs on the young plants in the hotbed, the leaves becoming yellowish and the underground part of the stem bluish in color. These plants generally die before or soon after transplanting. One of the commonest causes of poor stands in the fields is the early death of a large number of plants that became diseased in the hotbed. When the soil of the field contains this disease more plants become infected during the growing season. Such plants are distinguished by their yellowish or brown leaves, and by the blackened dead vines. They often have formed several potatoes, and after the disease kills the central stem these potatoes send up sprouts similar to those ordinarily produced in the hotbed. The typical appearance of plants thus affected is shown in fig. 13. Other plants affected still later may show no sign of disease until the stems are split during seed inspection at digging time.

Fig. 12.—Stem rot of sweet potato, showing the discoloration of vascular tissue. (U.S.D.A.)

Fig. 13.—Stem rot often affects plants as shown in the center—the vines have died and sprouts have grown out from the little potatoes already formed.

Fig. 14.—Soft rot, showing the luxuriant growth of the fungus on the surface, which often occurs in storage. (U.S.D.A.)

Scurf.—This disease is caused by a fungus that occurs in many soils, even where sweet potatoes have never been grown. It is most likely to affect potatoes on soils which are heavy or very moist. It causes small black spots on the skin which in severe cases run together, giving the potatoes a splotched or stained appearance. These diseased areas are superficial, seldom extending deeper than the skin, and doing no damage aside from producing their unsightly appearance. The disease is prevented to a large extent by the same methods as those given for black rot.

Fig. 15.—Ring rot of sweet potato—caused by same fungus as soft rot. (U.S.D.A.)

Soft Rot.—This disease occurs to a small extent in the field, but does its main damage during storage. It is caused by one of the most common molds, spores of which are in the soil and floating in the air everywhere. Fortunately, this mold is unable to penetrate the normal healthy skin, being able to enter the potato only through cuts and bruises. Hence, careful handling of storage stock lessens the chances of decay. Curing the sweet potatoes in warm dry houses just after digging increases their resistance to this decay, while cold, damp storage, as well as handling or sorting while in storage, greatly increases the chances of its occurrence. The same organism often produces a dry brownish decay known as ring rot. This usually

affects only portions of the tuber while soft rot renders the whole tuber mushy.

Nematodes.—Nematode injury, usually called root knot, occurs on sweet potatoes to some extent, but the injury to this crop is not so severe as it is to tomatoes, melons, and other garden vegetables. In fact, very satisfactory crops of sweet potatoes can be grown on soils so thoroughly infested with nematodes that it is impossible to grow most of the common vegetables and fruits. Nematode injury appears as small galls on the fibrous roots of the sweet potato plant, and as larger galls on the root end of the potatoes. Nematodes are easily spread from place to place by sweet potato plants; therefore, unless one is absolutely sure that the plants are free of nematodes, sweet potatoes should not be grown in young orchards on sandy land where nematode infestation would have serious and permanent results. Nematodes are most serious on light sandy soils. It is said that they can be starved out by growing crops immune to nematodes for two years. All cereal crops and the Iron and Brabham varieties of cow peas are immune.

THE DISEASE CONTROL PROGRAMME

The grower of sweet potatoes when once he realizes the losses caused by the common diseases, will wish to control not only one, but all of them, especially as he may not know which one of the diseases is doing the damage. Fortunately, the control of each of the common diseases requires practically the same treatments. No one treatment will be effective against any disease, hence, it is necessary to follow a programme of several distinct steps.

1. In the fall, healthy seed should be selected from healthy plants. The stems of the plants are split at digging time, and seed saved only from plants that show no internal discoloration. This selected seed should be kept separate from other potatoes in storage to avoid the possibility of infection. It should be stored in new boxes, or in old boxes that have been disinfected with bluestone solution (1 pound to 25 gallons of water).

2. Just before bedding time in the spring, the seed stock should be sorted over. All potatoes showing black rot or other decay must be discarded.

3. Make the hotbed in a new place each year or use fresh soil or sand in preparing it.

4. Do not let decayed potatoes become mixed with the soil or the manure used in making the hotbed, and do not leave them lying about near the bed.

5. Disinfect the seed before bedding, by dipping it for 10 minutes in a solution of corrosive sublimate (4 ounces to 32 gallons of water). See page 8 for details.

6. Discard all plants that show any evidence of disease when pulling for transplanting, especially those showing black or bluish discoloration on the basal portion of the stem.

7. Grow sweet potatoes wherever possible on land that has not been used for this crop in several years.

8. Try to grow healthy seed and healthy plants at home rather than buy them from some other section where diseases are likely to be just as common.

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