THE CULTURE AND DISEASES OF THE SWEET POTATO

BY THE SAME AUTHOR

THE CULTURE AND DISEASES OF THE SWEET PEA

DISEASES OF TRUCK CROPS AND THEIR CONTROL

DISEASES OF GREENHOUSE CROPS AND THEIR CONTROL

Each fully illustrated

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THE SOIL IN HEALTH AND IN DISEASE

E. P. DUTTON & COMPANY

THE CULTURE AND DISEASES OF THE SWEET POTATO

BY

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THIS BOOK

IS AFFECTIONATELY DEDICATED

TO

Dr. and Mrs. D. de Sola Pool

INTRODUCTION

THE time is rapidly approaching when, as a food, the sweet potato will share equal honors with that of the white potato. Although a tropical plant, its commercial value has been recognized by the American growers of the south who adopted it as an important money crop. Furthermore, it has become a staple food product in the average American home. The sweet potato is a typical truck crop, thriving best in light sandy loams. With this in mind, its future is unlimited. Texas alone possesses enough typical land to grow sweet potatoes for the entire population of the United States. Moreover, many of the southern states such as Alabama, Georgia and others can produce sweet potatoes sufficient to feed the entire world. With this crop rapidly coming into prominence and as knowledge of sweet potato storage increases, thereby reducing the losses from rotting, the day is not far distant when we will be in a position to export and to ship sweet potatoes to many of the European and Asiatic countries where this crop cannot be profitably grown on account of difference in soil or climatic conditions. The present great drawback to the more extensive production of sweet potatoes is its highly perishable nature, both in the field and in storage. It has been estimated by the Plant Disease Survey of the United States Department of Agriculture that in 1917 the loss from the more important sweet potato diseases was 32.37 per cent of the total crop, or a net waste of 41,706,000 bushels. In the foregoing estimate the losses from Texas root rot, *Ozonium omnivorum,* root knot, *Heterodera radicicola,* and from various insect pests, especially the weevil, were not considered. These if taken into account would swell the total loss to 38.19 per cent or a waste of 49,158,000 bushels of sweet potatoes. In estimating a general price of $1.10 during 1917, the total loss amounted to $54,073,800. During 1918 and 1919 the acreage of sweet potatoes in the United States was steadily increased so that the 1919 crop was estimated as 103,579,000 bushels. Due to the heavy rainfall during that year, the loss from rotting, both in the field and in storage, was considerably higher than in 1917, which a conservative estimate placed at 45 per cent of the total crop, or a direct waste of 46,610,550 bushels. In estimating the average price per bushel in 1919 at $1.50, the net loss to the American growers was $69,915,825. It is doubtful if the acreage during the last few years has increased considerably over that of 1919, so that the average production and the loss from diseases were about the same as for 1919. It is further doubtful if the sweet potato acreage will be reduced in the future and for the reasons given above it is reasonable to believe that it will steadily be increased. It is, therefore, evident that when an average annual loss of $69,915,825 is facing us, the challenge must be met by every progressive grower if this crop is to be placed on a profitable basis.

The present work has no apologies to offer. No one, more than the writer, realizes the shortcomings of this work. However, it should be remembered that our knowledge of the field and storage conditions of the sweet potato are, as yet, imperfectly understood, and the literature comparatively meagre. Recent studies by Hasselbring, Harter, Elliot, Taubenhaus and others have added considerably to our knowledge of the physiology and pathology of the sweet potato. However, much more remains to be found out. Much of the information here contained is first hand and represents laboratory research and field experience by the writer for nearly ten years. All other available data have been duly credited. Constructive criticism is earnestly solicited.

The writer is indebted to Professors A. H. Leidigh, W. H. Thomas and S. C. Hoyle, of the Texas A. & M. College for helpful suggestions in reading the manuscript. Acknowledgments are also due to many sweet potato growers of New Jersey, Delaware, Maryland, Virginia, Mississippi, Georgia and Texas for information on culture contained in the first part of this book. To the Agricultural Experiment Stations of Delaware and Texas the author is especially indebted for the use of all the original photographs taken by him and here presented. All other borrowed illustrations were properly accredited. Thanks are also due to Mrs. A. H. Leidigh for reading the part dealing with recipes; to Miss Stella Stuart, secretary to the writer, for assistance in preparing the index. Last but not least to my wife, whose moral support made this work possible.

J. J. TAUBENHAUS

COLLEGE STATION, TEXAS
March, 1923.

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PART I

CULTURE

CHAPTER I

ORIGIN AND PRODUCTION

Origin

During the last four hundred years, the sweet potato has fully established itself in the tropics and sub-tropics. Nevertheless, its true home of origin is still problematical. Humboldt, Meyer, and Boissier maintain that the sweet potato is of American origin, while Boyer, Choisey and others contend that its original home is Asia. The arguments in favor of its American origin are based on the contention that the fifteen known species of the genus *Batatas* are found in America, while only four of these occur in Asia. Moreover, Marcgraff described it from Brazil as *Jetica.* The name "batata" originated from a misinterpretation of "potato" which is really a Mexican word. When Columbus appeared before Queen Isabella he presented her, among his many presents, with a sweet potato which he found growing in America.

The sweet potato was not known among the Greeks, Romans, Hebrews, Arabs, or Egyptians. However, its supposed Asiatic origin is based on the contention that the Chinese Encyclopedia of Agriculture describes some varieties of sweet potatoes. On the whole, however, it is generally conceded that America was the original home of the sweet potato.

Distribution

The sweet potato is best adapted to the Southern States, yet it is grown as far north as New Jersey and as far west as central California. For successful commercial production the crop requires a growing season of at least four and a half months from field planting to fall frost, fairly warm nights, and a moderate amount of rainfall. It is also grown extensively in Mexico, Central and South America, Argentine, and Chile. In Africa, sweet potatoes are grown largely by the natives of all the European colonies, and by those of the interior. The crop is also well known in Mediterranean Europe and in Syria and Palestine. In Persia, Hindustan, India, China, Japan, and the Malay Archipelago it forms a staple food product. Sweet potatoes are also grown extensively in Australia and New Zealand.

Economic Importance

In the United States the sweet potato is second in importance only to the Irish potato as a truck crop. According to Miller (69*) the area in 1917 devoted to sweet potatoes in the United States was estimated to be 953,000 acres, the production 87,141,000 bushels, and the value $96,121,000. The farm value of sweet potatoes, which has doubled in the last ten years, has increased more rapidly than the acreage and production. This is no doubt due to improved methods of storing and marketing the crop. In the Southern States, the sweet potato is considered one of the principal food crops, and in recent years the acreage has been rapidly

* All numbers in parenthesis refer to Bibliography at the close of this work.

increased. Texas, for instance, hardly as yet produces enough to supply its own home markets, importing largely from Louisiana and Arkansas (Statistical figures not available). Table 1 shows the acreage, yield per acre, and value of the sweet potato for 1912 and 1913 in the United States.

TABLE 1

Acreage, Production, and Value of Sweet Potatoes, 1912 and 1913 *

States	*Acreage (000 Omitted)*		*Yield per Acre in Bushels*		*Total Production (000 Omitted)*		*Price per Bushel December 1 to Producers*		*Value Based on Prices December 1 to Producers (000 Omitted)*	
	1913	1912	1913	1912	1913	1912	1913	1912	1913	1912
	Acres	*Acres*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Cts.*	*Cts.*	*Dolls.*	*Dolls.*
New Jersey	23	23	138	120	3174	2760	78	84	2476	2318
Pennsylvania	1	1	110	120	110	120	90	75	99	90
Delaware	5	5	135	120	675	600	60	68	405	408
Maryland	8	8	141	125	1128	1000	60	63	677	630
Virginia	33	33	108	90	3564	2970	70	75	2495	2228
West Virginia	2	2	91	115	182	230	100	90	182	207
North Carolina	80	75	100	90	8000	6750	61	62	4880	4185
South Carolina	50	48	92	105	4600	5040	75	68	3450	3427
Georgia	83	81	87	90	7221	7290	68	66	4910	4811
Florida	21	21	110	112	2310	2352	75	73	1732	1717
Ohio	1	1	90	118	90	118	106	87	95	103
Indiana	1	1	78	116	78	116	103	89	80	103
Illinois	8	8	70	98	560	784	106	95	594	745
Iowa	2	2	80	90	160	180	150	108	240	194
Missouri	6	6	56	88	336	528	105	95	353	502
Kansas	5	5	50	99	250	495	110	103	275	510
Kentucky	9	9	75	90	675	810	94	85	634	688
Tennessee	20	20	80	90	1600	1800	80	72	1280	1296
Alabama	70	62	95	100	6650	6200	67	71	4456	4402
Mississippi	55	52	98	97	5390	5044	62	62	3342	3127
Louisiana	60	56	85	84	5100	4704	70	65	3570	3058
Texas	50	36	80	75	4000	2700	95	104	3800	2808
Oklahoma	6	4	64	92	384	368	104	109	399	401
Arkansas	20	18	90	88	1800	1584	80	90	1440	1426
California	6	6	170	156	1020	936	100	94	1020	880
United States	625	583	92.5	92.2	59157	55479	72.6	72.6	42884	40264

* Table 1 is taken from the U. S. Dept. Agr., Farm. Bul. 570, 1913.

Sweet Potato Production in Foreign Countries

Although the sweet potato is so extensively grown, data of production for other countries are very meager. According to Leon M. Estabrook, Chief of the Bureau of Crop Estimates, United States Department of Agriculture, no country of Europe, excepting Spain, published statistics on the production of sweet potatoes. They are practically unknown in the United Kingdom. In Spain the area in 1910 was 4584 acres, with a production of 48,600 tons, 2000 pounds to the ton.

In the 1907-8 Census of Argentina the area under sweet potatoes in that year is given as 30,107 acres. Statistics of agricultural production in all countries of South America, excepting Argentina, Chile, Uruguay, are practically non-existent. No statistics are known respecting sweet potato production in Africa.

Statistics as given by Daugherty (14) for Japan and Formosa show that in the former country for 1911, the area in sweet potatoes was 720,121 acres with a production of 4,156,052 tons (2000 pounds to the ton). In Formosa for 1911, the area in sweet potatoes was 265,156 acres, with a production of 747,305 tons.

Propagation

Sweet potatoes are propagated by means of seed sprouts and vine cuttings. Botanically speaking, the sweet potato is not a tuber like the Irish potato, which is considered an underground stem. It is, however, considered a root having dormant shoots near the lenticels. The sweet potato should not, therefore, be spoken of as a tuber as is so loosely done in the literature of this crop. It is seldom reproduced from seed obtained from fertilization of its blossoms.* Likewise it seldom if ever produces blossoms except in the tropical countries, in which case the flower resembles that of the morning glory. Gonzalo (25) states that in the Philippines, the varieties, Samar Big Yellow, Canegro, Sinomporado, and Beriberi flower profusely and produce true seed. In the United States the sweet potato is reproduced by means of roots which are generally spoken of as seed. Price (80) states that propagation may be effected by means of pieces of the root, in the same manner as the Irish potato is propagated. This method could only be used in warm climates where cold, damp weather is not likely to prevail in the spring. With this method, the root is sliced in two or more pieces and planted in the rows in the field about the same as are Irish potatoes. However, on a large scale, this method is impractical and expensive. It will require planting as many bushels per acre as for Irish potatoes. The standard method is to plant the roots in hot-beds, and as soon as the sprouts are large enough they are pulled and planted in the open field. The number of bushels required to supply the necessary sprouts per acre is indicated on p. 9.

The Seed (root)

It is poor practice indeed to sell out the choicest grade of sweet potatoes and to leave for seed "shoe strings," deformed roots, jumbos and culls. This practice, if allowed to prevail, may have a tendency to develop undesirable run-out strains. Johnson and Rosa (57) state that experiments at the Virginia Truck Station have generally shown no disadvantage in the use of small po-

* The term *seed potatoes* as it is used in this work refers to the edible root as it is also used for planting in the hot-bed.

tatoes, provided they come from healthy hills, This, however, needs further verification. The author (103) has shown that the use of the medium-sized roots when treated with corrosive sublimate will yield stocky sprouts. It is also claimed by many growers that such seed produce more vigorous plants. The smaller seed produce a larger number of sprouts, and this is why they are especially preferred by growers who sell plants. It is doubtful, however, if such sprouts are of a high quality. The use of jumbos for seed is not advocated unless they are cut up and treated with bichloride (see p. 24). Jumbo seed generally yield less sprouts in proportion to their weight, hence there is waste in hotbed space.

Seed Selection and Improvement

The only practical basis of selection is the hill unit (Fig. 1, a). The mistake is often made of selecting seed from the bins at the end of the storage season. In this case, where the individual root is the unit of selection, the largest potato may often come from a diseased hill or from a hill of low production, which we would not want to propagate. In selecting seed we should discard all hills which show disease of any kind. A search should be made for the highest yielding hills, and the potatoes from these should be stored and planted separately. Hills with less than five average, good, healthy, marketable potatoes should be discarded as unfit for seed. Hills producing numerous small and undersized roots should not be used. Selections by the average grower are generally made by going over the field during harvesting time and picking out the best producing hills. A more reliable method is as follows: The best looking field is picked, keeping in mind especially free-

Fig. 1. Seed Selection.

a. Ideal sweet potato hill suited for seed purposes. *b.* Showing method of hill selection in the field. *c.* Sweet potato digger (after W. H. Wicks).

dom from disease on the foliage and vines. The hills are then plowed out, two or three rows at a time, using the plow (Fig. 1, c) described on p. 73. Instructions are given to the picker to lift out each hill from the soil, without detaching any of the roots from the mother stem. This may easily be done by taking hold of the base of the plant and firmly lifting it out of the loosened soil. These hills are then carefully placed on a pile in the row, all the roots being put on the same side. Two or more of the most intelligent and reliable helpers should now sit down near the pile, and examine each hill, individually (Fig. 1, b), discarding the undesirable and saving the best. These are put away and stored in separate containers, and are carefully reselected in the spring to determine their freedom from rots before planting. It is suggested that a special "seed plat" area be carried by storage men, marketing associations and dealers in sprouts. Sprouts from seed of the best selected hills should be planted in separate rows. By this means, improvement may be made in shape and yield of the selected strains.

Number of Sprouts per Bushel of Seed

It is estimated that a bushel of medium-sized potatoes will produce 1500 to 2500 sprouts when three drawings are made. With rows four feet apart, and the plants eighteen inches in the row 7000 sprouts to the acre will be required. If the rows are closer than four feet, 8 to 12,000 sprouts may be required.

Sprout or Draw. By sprout is here meant the plants from a sprouted mother potato in the hot-bed. These sprouts are detached or drawn, and planted in the field. Growers frequently make one to three pullings from the same hot-bed. In many of the Southern States the term "slip" is used instead of sprout. The term "slip," however, may be misleading to some of the Northern growers, who infer it to mean vine cuttings. It seems desirable that the term slip should in this case be discarded and the word sprout adhered to.

Home-Grown Seed

For many reasons home-grown seed are to be preferred. They are especially desirable when the possibility of disease is considered. Without any pure seed laws or a system of inspection in many states we seldom if ever know whether or not the imported seed comes from disease-free land. There seems no doubt but that most of the sweet potato diseases were spread about promiscuously with imported seed. The grower in producing home-grown seed and sprouts is able to make his own selections, and to avoid infected fields. This fact is fully agreed upon by the most progressive growers. What applies to imported seed also holds true with the sprouts. It has been shown by Garcia (24) that imported sprouts die out much more quickly from disease than home-grown sprouts. This is very evident. Sprouts are nothing more than tender-rooted cuttings. If they are not immediately transplanted after "drawing," they will wilt, weaken, and become susceptible to all sorts of diseases. Frequently, imported sprouts are delayed three to five days from the time they were "drawn" to planting. When a large percentage of these sprouts die, we not only introduce disease in the soil, but the uneven broken stand results in reduced yields. Stuckey (93) found that home-grown plants produced heavier yields than shipped plants. This is shown in Tables 2 and 3.

TABLE 2

Yield of Home-Grown versus Purchased Plants

Variety	*Pounds Potatoes from Home-grown Plants*	*Pounds Potatoes from Purchased Plants*
Triumph	1055	725
Golden Beauty	853	555
Nancy Hall	771	602
Big Stem Jersey	630	533

TABLE 3

Yield of Home-Grown versus Purchased Seed

Variety	*Pounds Marketable Potatoes*	*Pounds Small Potatoes*	*Total Pounds Potatoes*
1912			
Golden Beauty, home-grown	773	80	853
Golden Beauty, ordered	406	149	555
1913			
Golden Beauty, home-grown	390	49	439
Golden Beauty, with one year's acclimatization	455	29	484

The difference in yield in favor of the home-grown sprouts may be due either to the set-back the plants received during shipping, or to a lack of acclimatization, or to disease.

STORAGE-HOUSE VERSUS BANKED SEED

There are growers in the Southern States who hesitate to use the so-called kiln-dried or storage-house seed, fearing that such seed germinate poorly. This, of course, has never proved true, since most growers store their sweet potatoes in kiln-dried warehouses only and no difficulty is ever experienced in the germination on that account. The prejudice against kiln-dried seed may perhaps be traced back to a few individual mishaps where seed have failed to sprout, not because of being kiln-dried, but because of soft rot in the hot-bed and previous rough handling and failure to disinfect against disease. It must be conceded that banked seed generally sprout earlier than kiln-dried seed, and for this reason are preferred by growers who sell plants. Such sprouts, however, are no better than those from kiln-dried seed. It is true the latter sprout more slowly but they produce stockier, firmer and healthier plants.

Seed Produced from Vine Cuttings

From the viewpoint of disease control seeds produced from vine cuttings are to be preferred. They may be easily produced in nearly all the Southern States, from Virginia to the coast. The seeds (roots) from vine cuttings are usually small-sized, but smooth, well-shaped, free from disease, and are only used the following year. The method of production is as follows: In the fall, during digging time, the roots from the best, selected, and healthiest hills should be stored away separately in containers and properly cared for. The following spring these seed are reselected for freedom from disease and the roots disinfected in bichloride of mercury (see p. 24). After the treatment they are planted in the hot-bed in the usual way. The sprouts from these are pulled and planted early in a field known to be free of disease, or if possible in new land. As soon as vines are produced, cuttings 8 inches to 12 inches long are made, and these planted as though they were rooted sprouts in a well-prepared soil. The roots which grow from these cuttings at the end of the season will be the seed from vine cuttings. These are to be stored away separately and the following spring planted in the hot-bed for the purpose of producing the sprouts for the main crop. Before planting out the vine cuttings, one should pinch off all the leaves except those at the tip. This will preserve the food of the cutting before it takes root. The tip of the vine is often too tender; hence it should not be used as a cutting. To get the best results, the cuttings should be ready to be planted in the field as soon as danger from frost is over. The cuttings are planted 4 to 5 inches apart in the row, the rows being about 32 inches apart. They are set either by hand or with the machine planter, and are inserted 4 to 6 inches in the ground and set firmly.

Some growers believe that where slip seed are produced, no more extra precaution is necessary to avoid diseases. This, however, is not the case. Slip seed are as a rule free from disease, because the vine cuttings which originate them are supposed to be healthy. However, if the cuttings are taken from diseased hills or planted in sick soil the resulting roots will not be free from disease.

Some growers in New Jersey, Delaware and Virginia claim larger yields from seed of vine cuttings. Others on the other hand prefer the sprouts to seed from vine cuttings believing that the latter method will eventually cause the strain to run out. This, however, is a disputed question with the balance in favor of seed from vine cuttings. The practicability of this method will largely be determined by the length of the growing season, and by the summer rainfall. Wherever possible, seed from vine cuttings should be produced at least once every second or third year. This practice will tend to elimmate soil stain (*Monilochaetes infuscans*); vine wilt (*Fusarium hyperoxysporum* and *F. batatatis*); and black rot (*Ceratostomella fimbriata*).

FIG. 2. FIELD OPERATIONS.

a. Transplanting machine for sweet potato sprouts. *b*. Hand transplanter. *c*. Flue-heated hotbed showing below, fire box, and above, the hotbed.

CHAPTER II

PROPAGATION

The Propagating or Hot-bed

By propagating bed is here meant any bed (irrespective of the method of heat used) where sweet potato seed (roots) are sprouted, and the sprouts used for field planting. The propagating bed requires as much care as the seed. Failure to recognize this makes it a breeding place for disease.

Location of Bed. The propagating bed should never be located near the sweet potato storage house (Fig. 2, c). The rotted potatoes which are frequently dumped out carelessly around the storage house will in due time be broken up and crushed by workmen and farm animals, and finally find their way into the hot-bed, infecting it with black rot and many other diseases. The ideal location is high, well-drained land, with unobstructed sunlight, protected from cold and preferably near the dwelling house. The south or southeast side of a thick wood will also offer a desirable place. In the absence of this the beds may be enclosed with a tight board fence, and in some cases a good windbreak on the exposed and windy side will suffice.

When early sprouts are desired, some form of heat is necessary. This may be supplied in various ways.

Manure-Heated Beds

Heat can be most cheaply furnished to the sprouting roots in the beds by means of manure. The general practice is to make an excavation 12 to 18 inches deep, under the frame which is about 6 feet wide, and as long as desired. The framework consists of 12-inch boards on the north or west side, and 6-to-8-inch boards on the south or east side, both ends being boxed up. The sides of the frame are held in place by stakes, or nails, or by dirt piled up on either side. The latter helps to keep out the cold. A more permanent hot-bed may be made by using concrete instead of boards for the walls.

The manure, preferably from the stable, should be turned once or twice to make it uniform in texture. It is then placed in the excavation to about 8 to 12 inches depth and well trampled down. If the manure is too dry, water should be added to it. When heating starts, clean sand is spread evenly over the manure to a depth of 3 to 4 inches, and planting is not safe until the temperature drops to 80 or 85 degrees F. After the hot-bed season is over the manure may be taken out from the bed and spread on the field or in the garden.

Manure is a cheap fuel and is abundant on the average farm. On large bed areas, and where manure is scarce, its price becomes too high to justify its use. Moreover, manure is apt to carry disease.

Flue-Heated Beds

Where manure is scarce, or too expensive, and where large quantities of sprouts are produced, flue-heated beds (Fig. 2, c) become very desirable. The best way to construct these is described by Price (81). The walls are constructed of concrete or boards, treated with creosote to preserve them longer. The frame is located on a well-drained place, sloping to the south or southeast, and protected from north or northwest winds.

The fire box is constructed of brick, 18 inches wide (inside measurements), 20 inches high, and 4 feet, 8 inches long. The terra cotta flue pipe, leading under the bed, is 8 inches in diameter, extending the entire length of the frame into the chimney at the other end. Some growers extend the flue pipe only two-thirds of the length of the bed. This, however, is dangerous as the escaping sparks often cause the bed to catch fire when the bottom is constructed of logs. The first 2 or 3 joints of the flue should be covered with brick, as a blaze from the fire box might cause it to become too hot and endanger the floor. The chimney may be made of brick or of 4-inch boards, nailed in box fashion. To draw better, the bottom opening of the chimney under the floor should be larger than the flue. The wooden floor is built 4 to 6 inches above the flue, to give a better distribution of heat and to prevent it from catching fire. The floor should have a slope of 12 inches in 90 feet or 1 inch to each 7½ feet. The flue under the floor should have the same slope as the floor; that is, the soil at the furnace end should be 18 inches deep and at the chimney end 6 inches deep. The soil on top of the frame should be level. The floor above the flue may be of logs or of any kind of rough lumber treated in creasote. The fuel for flue beds may consist of any kind of logs cut to fit in the fire box. It takes about seven loads of wood during the season to heat a 10×50 ft. flue bed. The advantage in this system is its cheapness of construction. The disadvantage is that the end nearest to the chimney is often coldest, and it takes the seed longer to sprout.

Steam or Hot Water Beds

Where a steam or hot water boiler is used in connection with a greenhouse, it may be conveniently employed for the sweet potato beds. On a large scale it will pay to install a steam or hot water system, even though it is used for no other purpose than sweet potato hot-beds. With this method the heat is better regulated, and maintained at a more even temperature.

With steam or hot water, the best results are obtained when the pipes are placed on the bottom of the hot-bed pit. The soil in this case is put on tile or on a board floor which rests on pipe or wood supports, a space of 3 to 4 inches being left between the floor and the bottom of the pit. According to Miller (69) the number and size of heating pipes required will depend on the rapidity of the circulation, on the pressure of the steam, or the temperature of the water. With hot water, and with beds not over 50 feet long, four 1½-inch pipes will suffice. For longer beds, 2-inch pipes should be used. Two of the pipes will serve as flow, and two as returns. The place where the pipes enter the bed should be the highest in the system, and where the pipes leave the bed, the lowest. The pipes should have a uniform grade, and be evenly spaced. The flow pipes should be laid about a foot from each outside wall, and the returns in the middle. With steam the arrangement is the same, except that smaller pipes are used. With steam at 10 pounds pressure, and for a 50-foot bed, 1-inch pipes are sufficient. For beds up to 100 feet long, 1¼-inch pipes are necessary. The boiler house may be 8 feet wide, 10 feet long, and 6½ feet deep below ground level. With a hot-water system, the heat is more evenly and regularly distributed and is more easily managed than steam.

Cold Frame

In many of the Southern States, no heat whatever is used in sprouting the seed. In this case, a pit is dug 10x50 feet and about 6 inches deep, bordered by a framework of boards, or the sides are banked up with soil. With this method, however, the sprouts are late. Protection from frost or cold is secured by means of a canvas.

Soil for the Propagating Bed

Experiments by Price (81) and by others have definitely proved that sweet potatoes bedded in sand produce plants with better rootlets than when bedded in clay or loamy soil. Neither fertilizer nor compost is necessary as plant food for bedded potatoes, as the sweet potato sprouts draw most of their nourishment from the mother potato. Moreover, from a hygienic point of view the use of clean sand for bedding will keep out many diseases which otherwise may be brought in with the manure.

Bedding the Seed

The time for bedding the seed for the production of sweet potato sprouts varies. As a rule, sweet potatoes are bedded about six weeks before the date on which it is expected to transplant the first lot of sprouts in the field. In most northern sections, sweet potatoes are bedded about a month before danger of frost is over.

The seed should never be bedded until the temperature of the hot-bed soil remains stationary at 78 to 80 degrees F. It is always necessary to have one or more thermometers in the hot-bed. The temperature should be read every day. The air temperature beneath the sash or cover should be maintained at not less than 60 degrees, or above 80 degrees F. During bright days plenty of ventilation should be given, by opening the sash or uncovering the bed.

The potatoes are planted by hand on the hot-bed soil, a space of ½ inch being left between each potato. It is best to bed all the seed of the same size together. In this way they may all be covered to the same depth. The very large ones may be cut in halves, lengthwise and laid in the bed flat side down. In order to hold the roots firmly and to prevent their disturbance or uprootings later when the sprouts are pulled, it is usually customary with growers in Delaware and Maryland to cover the seed with the sand or with a thin layer of pine needles. This is done in order to hold the mother roots when the sprouts are drawn. A better method, however, is that recommended by Price (81) and consists in covering the bedded potatoes with chicken wire. On top of this the seed are covered with a layer of 2 inches of clean sand. Frequently the seed are covered with 4 or 5 inches of sand. This, however, is a mistake, because the deeper the seed are covered, the longer and tenderer will be the shanks of the sprouts. This will mean tender plants which may be susceptible to disease. For treatment of the seed against disease see p. 24.

Covering the Hot-bed

Many growers often follow the practice of spreading a 2-to-3-inch layer of fine horse manure over the bed. This serves as a cover to preserve the heat or to retain the moisture. When the sprouts begin to appear, pa. t of the manure is removed to prevent the plants from becoming too spindling and tender. Many growers prefer the use of a layer of 6 to 8 inches of pine needles or straw instead of manure, while others cover the bed with dead sweet potato vines raked off and preserved from the previous season. From a disease consideration neither manure nor dried sweet potato vines should be used as a cover for the hot-beds. Both of these may carry or harbor the germs of black rot or any other of the fungi which cause disease in the sweet potato. Throughout the Gulf Coast and South-Atlantic States it is not always necessary to cover the beds for the purpose of preserving the heat or protecting the plants from cold. In the Northern States where sweet potatoes are grown, glazed hot-bed sashes 3 by 6 feet in size are greatly in use. In Delaware, in the eastern shores of Maryland and Virginia, as well as in many of the Southern States, a light canvas, or heavy muslin cover is all that is used to protect the hot-beds. When sashes are used they are made to slope to the south or east where the greatest amount of light can be admitted. When a muslin or canvas cover is used it is supported on lath or wire so that the rain water will run off readily. During bright days, the canvas or muslin is rolled up to admit sunlight and air. Before the sprouts are "drawn," they should be hardened. This is done by gradually removing all glazed or canvas covers. The sash or other covers should be put away in a safe and dry place, so as to preserve them for several years' use.

Watering the Hot-bed

Soon after the sweet potatoes are bedded and covered with the necessary sand the bed should receive a thorough watering. Later waterings are determined by the dryness of the soil. The quantity of water required will depend upon the method of heating used. Manure-heated beds will require less water than steam-or flue-heated beds. The beds should never be permitted to remain soaked for long periods, as this will weaken the plants and encourage disease, nor should they be permitted to remain dry too long.

It is, of course, more convenient to have water under pressure. Most plant growers make the hot-beds within the city or town limits on account of water facilities. Where potatoes are grown on a large scale, a well is often dug and the water pumped into an elevated tank or a series of barrels (Fig. 3, a), which are connected by watering hose. The water should never be applied under heavy stream pressure, as this may destroy the beds by washing out the roots and plants. During cool weather the beds should be watered during the warmest time of the day. In warm weather, watering in the morning is more desirable. Wherever possible, it is best to avoid watering the beds with very cold water, as the chill may injure the sprouts.

Other Care of the Hot-bed

Growers frequently go to all the trouble of carefully selecting and of treating the seed for disease, but violate all rules of hygiene. Diseased sweet potatoes are thrown about indiscriminately, and the rotted material is gradually crushed up and carried about by the wind, finally finding its way back to the hot-bed. Such carelessness should never be permitted. The seed should preferably be selected for freedom of disease before they leave the storage house. It is not a wise policy to take the seed out of storage, and do the reselecting near

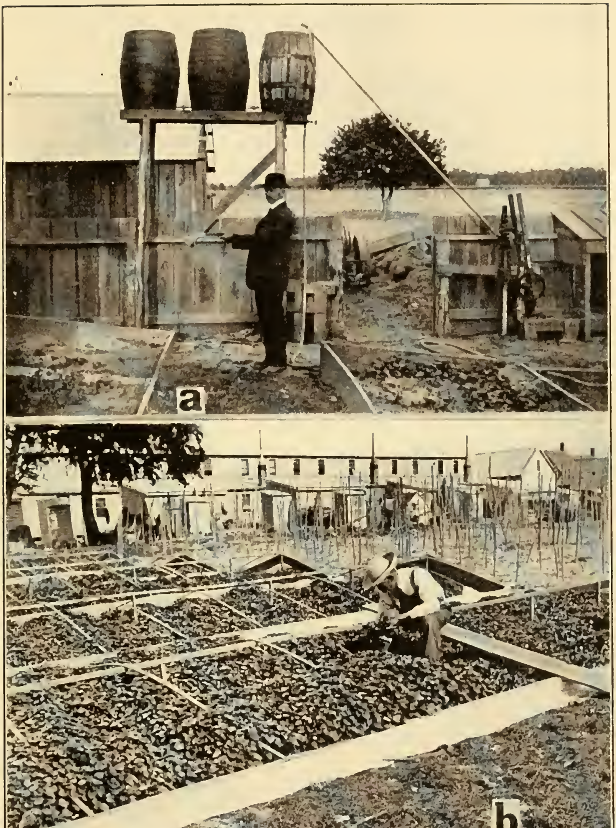

Fig. 3. Pulling Sprouts.

a. Showing water system arranged for watering sweet potato hotbeds. *b*. Ideal way of pulling sweet potato sprouts.

the hot-beds. With this method diseased material is scattered broadcast, and the purpose of the seed treatment is practically defeated by infecting the soil in the hot-bed from left-over and discarded roots. All diseased material should be destroyed by fire, buried very deep, or cooked and fed to hogs or chickens. When the seed is brought to the hot-bed for planting it should be free from disease. The beds should not be allowed to become chilled; nor should they be overheated, or lack the necessary ventilation.

Hot-bed Troubles

The sweet potato root is a very common carrier of diseases. Chief of these troubles which may be mentioned are black rot (see p. 141), scurf or soil stain (see p. 150), vine wilt or stem rot (see p. 154), and foot rot (see p. 139).

Not only should the seed be selected for freedom from disease in the field, but this should be done again at the end of the storage season and before planting. This cannot be carried out without a knowledge of the diseases which affect this crop. It is a thousand times easier to destroy seed which carry diseases than to attempt later to control these diseases when they have become thoroughly established in the field. Here the old dictum "one ounce of prevention is worth two of cure" holds true.

It is to the interest of the sweet potato grower to plant healthy seed. It is also furthering his interest and that of his community if he sees that no diseased seed is brought in or shipped out elsewhere. Pure seed laws in many states are sadly needed. Unfortunately, however, for the grower, the unscrupulous politician is fighting them with all his might. How some men can block such needed legislation is beyond comprehension.

Seed Treatment for Disease

It should be stated at the outset that if seed is diseased there is no cure for it. The sure remedy for this is to destroy by fire, or to boil and feed to stock. The seed treatment here recommended is only a form of insurance to protect the healthy roots from infection. Black rot may always be detected, because this disease works on the surface of the sweet potato. Roots showing this infection should not be used for bedding. With the stem rot or wilt, the disease can not always be detected by a surface examination. Seed suspected of carrying this disease may be easily tested as follows: With a sharp knife, clip the stem end of the root. A white interior surface will indicate a healthy potato. However, if the interior fibro-vascular bundles are brown, it is a sure indication that the seed carries disease, and hence should be discarded.

Before bedding, and after the seed have all been selected for freedom from disease, they should be soaked for ten minutes in a solution of one ounce of corrosive sublimate dissolved in eight gallons of water. The purpose of this treatment is to kill all the germs of disease which may adhere to the outside coat of the sweet potato.

Corrosive sublimate, also known as bichloride of mercury, will corrode metal ware; hence it should only be dissolved in wooden vessels, such as tubs, tanks, or barrels (Figs. 4, d and 4, e). On a large scale enough of the solution is prepared for the treatment of 50 bushels at one time. The sweet potatoes are placed in a slatted

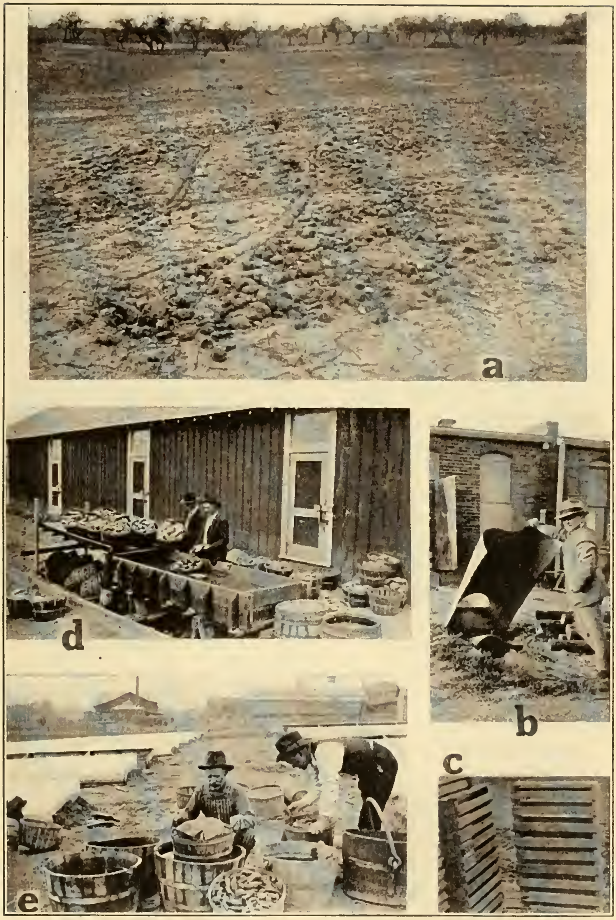

FIG. 4. DIPPING SWEET POTATO SEED.

a. Diseased sweet potatoes spread out in the field as a fertilizer (bad practice). *b*. Pipe ventilator for introducing air into a sweet potato storage heating system placed in the cellar. The pipe is uncovered to show its outside opening. *c*. Slatted box often placed in the center of the bin for ventilation purposes. *d*. Dipping sweet potatoes in wooden dipping vats. *e*. Dipping sweet potatoes in half barrels.

container or burlap sack, and plunged in the bichloride solution, and the whole is submerged for ten minutes. There will be no appreciable harm, if the potatoes are left a few minutes longer in the solution. Where "safety first" is the rule, this should not be done. The bichloride dissolves more readily in lukewarm, than in cold water. According to Weimer (109), each bushel of sweet potatoes treated in mercuric chlorid solution prepared at the rate of one ounce of the bichloride in eight gallons of water reduces its strength by one per cent. This decrease in strength of the mercuric chlorid solution is due largely to the potatoes and to the dirt which absorb the solution during the treatment. To offset this loss, from three-fifths to one-half ounce of mercuric chlorid and sufficient water should be added to make the solution up to its original volume after treating 10 bushels. This will maintain the solution near enough to its original strength for the treatment of 50 bushels of sweet potatotes.

After the seed have been soaked in the bichloride solution for ten minutes, they are taken out immediately, and the excess liquid is allowed to drain off. They are then ready to be planted at once in the hot-bed. In fact, the treatment should immediately precede the bedding. The treated seed should never be washed with water, as to do so will remove the disinfectant and defeat the purpose of the treatment.

Bichloride of mercury is a violent poison when taken internally. The bottle containing this chemical should be conspicuously labeled Poison. Care should be taken that no farm animals or children are allowed to drink by mistake from the solution in which the seed are to be treated.

Some growers believe that if corrosive sublimate is a poison, then any other chemical poison can readily take its place. The author has actually met with several cases where Paris Green was used instead of corrosive sublimate. The corrosive sublimate here recommended is used to kill fungus spores only. Paris Green, however, is used only to kill insects; it is not a fungicide.

Diseases Affecting Sprouts in the Hot-bed

It becomes self-evident that if the seed are diseased at bedding, these same troubles will be communicated to the sprouts later. Health and vigor in the seed bed are indicated by sprouts with deep green foliage. This condition is to be met with where sand is used and where the seed were carefully selected and treated for disease. Disease in the seed bed is usually indicated by a paleness of the tip leaves, a general pale color of the entire sprout, and cessation of growth. Usually the presence of disease is manifested in spots. On a closer examination we may find that the diseased spot is restricted to the sprouts of a single mother root. When the latter is pulled out, it will usually be discovered that the rootlets of the sprouts have either rotted away or have blackened. This condition may be due to black rot. In more severe cases, the shanks and sometimes the stems of the sprouts will be affected. In this case, the sprouts are stunted, rotted at the base, and have little or no root system. Pale spots in the hot-bed indicate presence of disease. This paleness, however, should not be mistaken for a whitening of the plants when kept covered too long under the canvas. If this is the case, the plants soon regain the normal deep green when exposed to the sunlight. There are some growers who insist that dead or blackened rootlets of the sprouts are no signs of disease, but that these are due to the scorching of the heat from flues. While, as already stated, flues often burn sprouts in the bed, yet the burning effect is indicated more as a browning and wilting of the rootlets than as blackening, which is so characteristic of the black rot. Moreover, diseased spots are not confined to flue-heated hot-beds, but they are very common in beds heated by manure or by hot water. In fact, diseased spots are a common occurrence in every bed where no attention is paid to the selection of the seed or to seed treatment. Perfectly healthy sprouts, when pulled out, possess an abundance of white long roots. It is only where such plants are used that a clean crop is to be expected.

As soon as disease is detected in the hot-bed, an area including infected roots, sprouts, and soil should be removed and replaced by clean sand. The water should be withheld slightly, the temperature lowered, and, if possible, plenty of ventilation given. If there are too many diseased spots in the bed, it should be abandoned and its sprouts not used.

Certified Seed

There is an increasing demand for seed sweet potatoes which are free from disease. The progressive grower is fully alive to the danger of buying his seed indiscriminately and of taking chances of introducing dangerous diseases to his field. The sooner we come to demand certified seed for sweet potatoes as is done with the white potato, the more rapid will be the increase in acreage and in profitable production. The state of Arkansas is now leading in educating its growers to the necessity of certified seed. The system employed is described in Circular No. 9, 1920, of the Arkansas State Plant Board, which is here reproduced as a sample of what may be done by other states.

Inspection Service in Arkansas

Application for Inspection

Rule 45. Any person growing Irish or sweet potatoes for seed may have such seed inspected by applying to the Chief Inspector on or before March 1, for the inspection of spring grown seed Irish potatoes and on or before July 15 for the inspection of seed sweet potatoes or fall grown seed Irish potatoes. Such application for inspection shall set forth (a) the location of the place where the seed is grown with reference to the direction and distance to the nearest railroad station, (b) the number of acres to be inspected, (c) the varieties of potatoes, (d) the distance between the blocks of growing seed stock and (e) such other information as the Chief Inspector may need in estimating the time required for inspection.

Fees for Inspection

Rule 46. For the inspection of seed Irish or sweet potatoes as provided in Rule 45, the Chief Inspector shall charge fees as follows:

(a) 'A' fee of $5.00 to be paid at the time that the application for inspection is made.

(b) An additional fee of $1.25 per acre, for each acre which it is desired to have certified. The latter fee to be paid before the second inspection is made.

(c) An additional fee of $5.00 for each extra inspection which may be warranted as a result of the findings of a previous inspection.

Applicants must furnish the inspector transportation from and to the railway station and facilities for reaching his fields of seed stock.

Applicants may withdraw their applications for inspection by notifying the Chief Inspector within 15 days after receiving from him the report on the first inspection.

Requirements for Certification

Rule 47. All seed Irish or sweet potatoes for which certificate of inspection is desired must be inspected at least twice. (a) when the seed crop is growing and (b) at digging time, or if the Chief Inspector shall so elect, after the potatoes have been stored. Applicants must have their seed crop in a clean state of cultivation and in such condition otherwise that all plants can be easily seen by the inspector.

(c) Upon proper fulfillment by the grower of the seed potatoes of all requirements, prescriptions and conditions set forth in the notices issued said grower by the Chief Inspector, he shall be issued a certificate of inspection in form as hereinafter set forth in the rules of the Board.

Certification of Slips

Rule 48. The Chief Inspector may issue a certificate of inspection covering sweet potato slips to any person who shall grow his sweet potato slips from seed sweet potatoes for which a certificate of inspection was issued under the provision of Rule 46 when such seed sweet potatoes were bedded in accordance with directions furnished by the Board. Applications for a certificate under the provisions of this rule must be made to the Chief Inspector 30 days before the sweet potatoes are to be bedded, and must be accompanied by a fee of $1.00. The sweet potato slip certificate shall be in form as hereinafter set forth in the rules of the Board.

Labelling Requirements

Rule 50. Holders of certificates of inspection granted under the provisions of Rules 47 and 48 of the Board must attach to each carload, sack, hamper, basket or package of sweet or Irish potatoes or sweet potato slips covered by their certificate, a tag bearing a copy of said certificate with the fac simile signature of the Chief Inspector. Said tags to be purchased at cost from Chief Inspector.

Whenever a holder of a certificate of inspection as provided in Rules 46 and 47 shall sell or ship seed sweet or Irish potatoes or sweet potato slips which are not covered by a certificate issued by the Chief Inspector of the Arkansas State Plant Board he shall attach to every carload, sack, hamper, basket or package of such sweet or Irish potatoes or sweet potato slips a tag bearing, in letters not less than ¼ in. high, (24 point type) the words "Not Covered by a Certificate of Inspection from the Arkansas State Plant Board."

All Sales of Seed and Slips Must Be Registered

Rule 54. Every holder of a certificate granted under the provisions of Rule 47 or 48 of the Board must file with the Chief Inspector, at the end of each week, a copy of each sale or disposition of seed or slips made by him during that week.

Each invoice shall be made out on a separate slip (form to be provided by the Chief Inspector) and shall set forth the following information:

(a) Name of the certificate holder disposing of the seed or slips.

(b) Date of disposition or shipment.
(c) Person to whom the seed or slips are disposed of.
(d) Number of bushels, or slips, of each variety disposed of.
(e) If seed is disposed of, whether it is certified or uncertified.
(f) If certified seed or slips are disposed of, the number of certificate tags used for the sale or shipment must be recorded.

Holders of certificates must also account for every certificate tag purchased from the Chief Inspector and all unused or defaced tags must be returned to the Chief Inspector at the expiration of the certificate of which the tags bear a copy.

Seed Certification

The first inspection for certified seed is made when the crop is in the field. The inspector goes down every other row or every fourth row (depending upon the size of the plants and on the experience of the inspector) and sees every hill. If a single sweet potato hill is found to be infected with stem rot (wilt) the field is disqualified for certification. In the case of Irish potatoes the field is disqualified if more than five per cent of the hills are found to be infected with "curley top" (mosaic). All hills infected with curley top must be dug up. Fields of Irish potatoes infected with wilt will be rejected for certification. All fields of Irish or sweet potatoes which pass the first inspection are eligible for the second inspection.

The second inspection is made at digging time or else after the potatoes are stored. In the case of sweet potatoes the second inspection must show the potatoes to be free of black rot. The second Irish potato inspection is for scab, Rhizoctonia, or other diseases. Should these diseases appear in quantity warranting it, a certificate will be refused.

In addition to the diseases mentioned, the presence of any other diseases may disqualify the potatoes for certification if, in the opinion of the Chief Inspector, they are serious enough to warrant it.

After a grower's potatoes have passed two inspections he is granted a certificate on the filing of an affidavit in form as shown on page 6. A letter from the Chief Inspector accompanies each affidavit and makes such reservations or restrictions as the particular case may demand.

Potatoes may be reinspected at any time the Chief Inspector may deem it necessary and on the findings of such extra inspections certificates may be revoked or additional restrictions may be imposed.

Slip Certification

No inspection is made for the certification of sweet potato slips. The slips, however, must be grown from seed certified by the Arkansas State Plant Board and the seed must be treated and bedded in accordance with directions furnished in Type Circular No. 12. No slip certificate is furnished to any one who grows any but certified slips. In other words, the applicant for a slip certificate must either grow all certified slips or none.

After the grower has followed out the requirements for bedding his seed, he must sign an affidavit as shown on page 7. When the grower purchases his certified seed he must have the person from whom he purchases it file an affidavit (form furnished by Chief Inspector) showing that the certified seed was actually sold to the applicant for the slip certificate.

Registration Requirements

In accordance with the provisions of the Board's Rule 54 every sale of seed or slips which is made by a certificate holder must be registered with the Board. Special slips are provided for the purpose, and these must be turned in once a week. The object of this rule is to protect the certificate holders and also the purchasers of certified seed against the misuse of a certificate.

Labelling Requirements

Because of the fact that many fields of potatoes are disqualified for certification, some growers have both certified and uncertified seed for sale. For this reason Rule 50 of the Board requires holders of certificates to label EVERY sale or shipment of their seed. If the seed is certified it must bear a tag showing copy of the certificate of inspection. If the seed is not certified it must be conspicuously labelled in accordance with the provisions of Rule 50 showing that it is not certified by the State Plant Board.

CHAPTER III

DRAWING SPROUTS

Ordinarily the "drawing" of sprouts is done by unskilled labor or by children. It is essential that the potato grower should instruct his help how to recognize diseased plants in order that such material may be prevented from finding its way to the field. It will even pay to have reliable helpers reselect all the pulled sprouts and discard those that show the least sign of disease. This must, of course, be done in the shade and not in the hot sunshine. It is expected that when the sprouts are ready to be transplanted in the field they will be free from disease, for ordinarily, any one feeding the sprouts to a transplanting machine will have no time to discriminate between healthy and diseased plants. In drawing the sprouts one should avoid trampling on the seed bed as far as it is possible to do so. This is particularly important when the grower expects to make more than one pulling from his bed. Walking on the hot-beds results in injury to the mother roots, which opens the way to disease, particularly soft rot. Trampling the beds may be avoided by placing a plank for the worker to sit on (Fig. 3, b) The plank is moved forward with the advance of the pullers. It is always best to set the sprouts in the field soon after a rain. The plants are, therefore, pulled soon after the rain and placed in crates or baskets, and covered with straw or some burlap to prevent wilting. When "drawing" the plants, one should hold the mother potato down with one hand, and remove the sprouts with the thumb and finger of the other hand. If several plants cling together, they should be separated, as this should not be left for the planter in the field to do.

It is a good practice to puddle the plant, that is, plunge the roots in mud, which should be made up of water, clay, and cow manure, and stirred until it forms a thin slime. If the puddled plants become dry they should be repuddled before planting.

Number of Draws per Hot-bed. The number of draws to be made from a single bed usually depends on the grower. Some prefer but one pulling, while others make two, and still others, and particularly those who sell sprouts, make three draws. The best sprouts are naturally those of the first pulling. The reason is obvious, since the sprouts of the first pulling feed on the mother roots, which, under the average conditions, are as yet sound. After the first drawing, the mother roots are nearly always disturbed and injured, so that many soft-rot. The result is that the weak sprouts which have now been left over must shift for themselves, which means weaker plants. The third pulling, therefore, is often of a decidedly inferior grade. Not only is there a noticeable difference of vigor in the beds, from the first to the third pulling, but there is also a difference of vigor in stand in the field from these pullings, and furthermore there is a difference in the keeping qualities of the respective yields in storage. It is very probable that most of the rotted material dumped out of storage houses could be traced back to weak sprouts from the third pulling.

Buying or Selling Sprouts

It is safest, from a disease consideration, to produce one's own seed sweet potatoes and sprouts. Next to that it is far safer to buy seed and sprout them at home than to buy sprouts. It is much easier to judge the quality of the seed when bought, than it is to judge the sprouts, for in this case the quality of the seeds which produced these sprouts is unknown. If we are compelled to buy sprouts, it is safest not to order them from long distances, but rather to secure them from our nearest neighborhood. No matter how well sprouts are packed, they must suffer a severe shock from travelling two or three days in the mails or by express. In preparing the plants for shipment, it is best to bring all the "drawn" sprouts to a shed where the plants may be tied with soft string in bunches of 100 each. The tips of the sprouts should always be dry when packed, as otherwise they will rot when shipped. Damp moss or paper may be wrapped around the roots in the crate or basket, but the tops should be dry and given ventilation.

Cutting Back Sprouts. Where the mother roots are planted and covered too deeply in the hot-bed, the shanks of the sprouts will invariably be too long. As already pointed out, there is little to be gained by planting a sprout with a long shank. Such plants are tender and usually take black rot in the field much more quickly than a stocky sprout with a short shank. Shanks longer than two inches may be safely cut back at the root end without any injury to the sprout. This is particularly helpful where the hand planter is used.

Dipping Sprouts. Work by the author (103) has shown that it is not necessary to dip the sprouts after being pulled from the seed bed and before planting in the field. This is especially unnecessary where clean sand has been used in the hot-bed and where the seed have been carefully selected and treated for disease. Dipping sprouts in the same strength of corrosive sublimate as is recommended for the seed is unsafe, as serious injury may result. On the other hand, if the sprouts are merely dipped and taken out of the solution, no particular benefit is to be expected and this will only entail unnecessary labor and expense.

Transplanting

Transplanting in the field is done as soon as the soil is warmed up and danger from frost is over. In Virginia, setting out is begun early in May and continues up to the middle of June. Duggar (15) states that the safest time to set out sweet potato sprouts for an early crop is as follows: Near Jacksonville, Fla., March 20 to April 1; in South Carolina, Georgia, Alabama, Mississippi, and Arkansas, April 1 to 25. In New Jersey and Delaware, the latter part of May is the best time for the main crop, while in the Gulf states, May and June are best. Very early planting is desirable for early marketing at high prices. For the main crop which is to be stored, transplanting should be done when cool weather is over, and the soil warm. For early potatoes, there should be a period of 60 to 75 days between transplanting and digging.

No set rules can be laid down for the best date of transplanting. This will depend on the variety and the locality. Experiments on the Pumpkin Yam by Stuckey in Georgia (see Table 4) show that year in and year out there is no one best date for transplanting. However, under Georgia conditions, light yields are to be expected when transplanting is made after July 1st. The latter part of May seems to be about the best time for the Pumpkin Yam type.

TABLE 4

Effects of Date of Planting on Yield of Pumpkin Yam Sweet Potato

Date Planted	Pounds Marketable Potatoes	Pounds Small Potatoes	Total Pounds Potatoes
April 23, 1910	141	71	212
April 30, 1910	160	67	227
May 12, 1910	250	55	305
May 24, 1910	182	56	238
June 1, 1910	259	73	332
June 11, 1910	412	63	475
June 21, 1910	275	43	328
July 1, 1910	314	54	368
July 15, 1910	44	14	58
July 30, 1910	0	4	4
May 6, 1911	410	238	648
May 16, 1911	506	271	777
May 26, 1911	241	136	377
June 5, 1911	258	148	406
June 15, 1911	203	96	299
June 25, 1911	185	97	282
July 5, 1911	109	88	197
July 15, 1911	146	85	231
July 25, 1911	23	12	35
May 20, 1913	346	88	434
May 30, 1913	272	86	358
June 6, 1913	212	70	282
June 19, 1913	244	62	306
June 28, 1913	0	178	178
July 7, 1913	0	106	106
July 17, 1913	0	34	34
July 28, 1913	0	14	14
August 9, 1913	0	0	0

Ridge versus Level Culture. Local conditions usually determine whether to plant on low or high ridges or on level surface. In some of the Southern States, where the rainfall is uncertain, ridge culture is not practiced. The soil moisture is rapidly lost from high ridges, and this is not the case with low ridges, or flat surfaces. Ridge culture is desirable in localities with high rainfall, as it affords good drainage. For early maturity, ridge culture is the general practice, for the reason that the soil becomes warm sooner than it otherwise would.

When level culture is practiced the rows are marked off both ways with a cleated roller or with a drag marker run by hand; or by one horse. The plants are set out at the intersections of the marks, that is, in a 28-inch check, to allow for cultivation in two directions. Where ridge culture is practiced, the ridges are made with a turn plow. In rich land the ridges are made 28 to 30 inches apart, and the plants set 14 to 18 inches apart in the row. On the poorer sandy soils, the ridges are 32 to 48 inches apart and the plants set 14 to 24 inches apart in the row. The number of plants per acre should be determined by the kind of soil and the fertilizer used. Varieties with heavy vine growth will naturally require more room than those with small vine growth.

The method of setting out the plants will depend upon local conditions. The essential thing is to set out a healthy, well-hardened sprout, and to place its roots in contact with moist soil. Much water is not necessary at the time of transplanting. About half a pint per plant is considered sufficient. However, under climatic conditions similar to those of New Mexico, irrigation is recommended as soon as the plants are set out. Ordinarily when the hand planter (Fig. 2, b) or the transplanting machine (Fig. 2, a) is used, the amount of water is automatically regulated. The best practices in the setting out of sprouts, regardless of the method used, are given by Mooring (70) as these: The roots are placed in moist, pulverized soil; the openings are made large enough, so that the roots may be spread out; the soil is pressed firmly about the roots. Where the roots are puddled, the mud is not permitted to dry on the roots before they are planted.

Tools for Transplanting. On a small scale, where only a few hundred plants are set out, planting by hand will answer the purpose. Here a dibble or a trowel could be used to advantage. On a larger scale, however, setting by hand is very tiresome, and hard on the back. In this case a pair of wooden tongs may be used. With this instrument the plant is caught by the root and thrust into the soil, the sprouts being carried by the operator in a small basket strapped to the waist. The tongs possess a spring capable of throwing the jaws apart, and are thus held in one hand while the plants are inserted with the other. Frequently, in connection with the tongs, an implement known as a shovel is also used. This consists of a lath sharpened to a flat point and is used to open a hole in the soil for the plant to be set in. With this implement, the plants are dropped as for hand planting. The operator who does the planting carries the tongs in the left hand and the shovel in the right. A hole is made with the shovel at the point where the sprout is to be set. The plant is then picked up with the tongs and inserted in the hole, and the earth firmly pressed around with the foot or by a second thrust of the shovel. An experienced man is capable of setting out ten to twelve thousand plants in a day with these implements.

Machinery

Where large acreages are devoted to sweet potatoes the grower relies mostly on transplanting machines (Fig. 2, a). The main features of these consist in a device to open a small furrow, a tank to supply the water, and disks and blades for closing the soil about the plant. To operate the machine, it is necessary to have a steady team, and two well-trained hands who can drop the plants as indicated by the spacer on the machine. With this device, the plants can be set out at any season, since water is furnished by the machine. Under favorable conditions one machine will set out 3 to 4 acres per day. Most transplanting machines are designed either for ridge or level culture.

Replacing Dead Hills. It is not uncommon to find many dead hills soon after transplanting in the field. Before replacing missing plants one should determine the cause of their dying. Cut worms often do considerable damage, but these should not be tolerated, as they may be controlled with poisoned bait. Hills killed by cut worms or by frost may be replaced. However, if it is found that the plants died from black rot or "stem rot" no attempt should be made at replacing. (For symptoms of these two diseases see pp. 141 and 154). Healthy sprouts, when set out in diseased hills, will readily contract these diseases themselves. Sprouts will usually die soon after transplanting, if the soil is infected or the plants were diseased to begin with. Both of these conditions should be avoided.

Soil Requirements

The best sweet potato soil is a sandy loam with a clay subsoil. Under these conditions, harvesting is easy, and the quality and appearance of the potatoes are very desirable.

In heavy soils the roots are rough and have a tendency to crack during active growth in wet seasons. Stiff clay soils tend also to produce heavy vine growth, and long irregular roots, which are inclined to be watery; hence difficult to cure and keep. Dark muck soils may be adapted for sweet potatoes, provided they are well drained and thoroughly worked. Sweet potatoes often thrive well in clean sand, where commercial fertilizer has been added. Fair yields may be expected on worn-out cotton and tobacco lands in the South, provided a good system of rotation is adopted, and a leguminous crop turned under to add humus to the soil. Sweet potatoes are well adapted to newly cleared timber land, such as cut-over pine land in the South. However, in this case, it is far more advisable to grow a corn crop the first year and then follow it with sweet potatoes. In newly cleared land the roots of trees and stumps will greatly interfere with thorough cultivation of the sweet potato.

When sweet potato land is chosen, its drainage should not be overlooked, as this is very essential for the best results. The surface soil should be six to eight inches deep, and underlaid with a porous clay subsoil capable of carrying off the surplus water, and yet of preventing the leaching out of the fertilizers which are applied every year. Deep surface soil with a sandy or very porous subsoil should be avoided for sweet potatoes. Such a land will produce long stringy potatoes, which are unfit for the market. On the other hand, there is no objection to a shallow surface soil, as it may be deepened every year by cultivation.

Together with soil considerations, we must remember that the sweet potato is very sensitive to frost. It should, therefore, be planted on the more elevated sections of the farm. This will secure the longest growing season, make possible early planting, and insure a longer fall season for the final maturity of the crop.

Preparation of the Soil

In the rich, sandy loams, it is not uncommon for most of the potatoes to grow to the jumbo size. These are, of course, disliked by the market, and the grower is always confronted with the difficulty of disposing of his crop. Rich, sandy lands, which produce large potatoes, should be plowed shallow, not over three to four inches deep. Stiffer, less porous soils should be plowed deeper with a two-horse turning plow to "break it broad-cast" so as to prevent the formation of small potatoes, altogether. This is usually done in the spring, and is followed by a cross discing; that is, the land is disced both ways, if it is level. On terraces, this cannot be done. In light soils, one discing should be sufficient. The disc harrow is then followed up with a spring tooth, acme, or spike tooth harrow. This, however, is done only where the plants are set out in flat rows.

Rotation

From the standpoint of disease control, increased production, and soil improvement, the best results are obtained with sweet potatoes where a careful system of rotation is adapted. Careful seed selection and a rotation where sweet potatoes will grow on the land every third or fourth year, will tend to eliminate dangerous diseases. By this method black rot, foot rot, stem rot or wilt, and pox, will be prevented from becoming permanently established in the land. No rotation is complete if it excludes a leguminous or other green cover crop to be worked in. Cowpeas, soy beans, velvet beans, or crimson clover, as they are variously adopted, will make good cover crops. In Virginia, Maryland, Delaware and New Jersey, when the potatoes are dug for early market, crimson clover may be sown as a cover crop after the sweet potatoes. This is possible only if the potatoes are off by September 1st to the 15th in New Jersey, Delaware, and Maryland; and by September 30th in southern Virginia. If the potatoes are dug too late for planting crimson clover, a cover crop of rye, oats, or vetch will offer an acceptable substitute.

Although no fast rule can be laid down, the rotation advised by Miller (69) is here recommended and is as follows:

FOR THE COTTON BELT WHERE SWEET POTATOES ARE GROWN AS A FARM CROP

A. *First year.*

a. Cotton, followed by rye for winter pasture or as a crop to turn under; or

b. Corn, with cowpeas or velvet beans planted as a soil improving crop.

Second year. Sweet potatoes, followed by winter cover crop of rye, or oats and vetch.

Third year. Oats, followed by peanuts or cowpeas.

B. *First year.*

Sweet potatoes, followed by a winter crop of rye, or oats and vetch.

Second year. Cotton, with rye sown between the rows for winter pasture or to turn under.

Third year. Corn, with cowpeas or velvet beans planted as a soil improving crop.

FOUR-YEAR ROTATION FOR THE SOUTHERN SWEET POTATO SECTION

First year. Sweet potatoes.

Second year. Winter oats, followed by peanuts or cowpeas.

Third year. Cotton.

Fourth year. Corn, with cowpeas or velvet beans between the rows.

THREE-YEAR ROTATION FOR THE EASTERN SHORE OF VIRGINIA AND MARYLAND

First year. Sweet potatoes, followed by crimson clover or rye as a winter crop.

Second year. Early Irish potatoes. On many farms corn is planted between the rows of potatoes at last cultivation; on other farms the potatoes are followed by fall vegetables.

Third year. Winter oats, followed by cowpeas for hay.

Chemical Fertilizers

Sweet potatoes, as every other crop, do remove certain fertilizing elements from the soil. This is shown in Table 5 by Keitt (58).

TABLE 5

Fertilizing Elements Removed by a Crop of Sweet Potatoes

Variety	Bushels per Acre	Total Per Cent Acid Phosphate	Per Cent Nitrogen	Equivalent to Ammonia	Per Cent Potash	Value Removed per Acre
Nancy Hall.........	270.0	0.0573	0.280	0.332	0.445	$11.75
Polo...............	281.0	0.0768	0.243	0.295	0.479	11.83
Southern Queen.....	416.0	0.0775	0.243	0.295	0.492	16.72
White Spanish......	141.0	0.0798	0.236	0.287	0.434	5.67
General Grant......	191.0	0.0773	0.214	0.260	0.388	8.12
Brazilian..........	450.0	0.0553	0.271	0.329	0.534	20.69
Arkansas Beauty....	158.0	0.0869	0.266	0.323	0.519	7.26
Tennessee Notchleaf.	281.0	0.0435	0.245	0.298	0.343	10.55
Yellow Nancemond..	214.0	0.0519	0.213	0.259	0.390	7.62
Purple Yam........	180.0	0.0525	0.292	0.355	0.506	8.54
Pumpkin Early Yellow Yam.........	270.0	0.0840	0.348	0.423	0.684	16.04
Shanghor Yam......	174.0	0.0621	0.184	0.229	0.336	5.51
Vineland Bunch Yam	141.0	0.0893	0.231	0.281	0.392	5.45
Fulleton Yellow Yam.	326.0	0.1069	0.283	0.344	0.382	14.82
Average......250 *bu.*						$10.73
Cost of fertilizer removed per bushel..................						$ 0.043

The judicious use of commercial fertilizer will insure increased yields. No fast or hard rule, however, can be laid down as to kind and quantity. These two things will largely depend on the soil requirements and on climatic conditions. In the Northern States where sweet potatoes are grown, the crop must mature in the shortest possible time. Here then, heavy application of a high-grade commercial fertilizer is practical. A fertilizer analyzing 2 to 4 per cent available nitrogen, 8 per cent phosphoric acid, and if possible, 8 to 10 per cent potash should give good results, for this is really a rich mixture. However, with the present scarcity of potash, it is omitted altogether or used in amounts of 1 or 2 per cent. The quantity of fertilizer to apply should depend upon the fertility of the soil and the system of crop rotation used. In New Jersey, Maryland, Delaware, or Virginia, it is not uncommon for growers to apply 1000 to 1500 pounds per acre, either broadcast or in the row.

In the sandy loams of the South, where the season is long, and the climate well adapted, the application of high-grade fertilizer is not always essential. Fair returns may be expected from the use of a fertilizer which consists of one part of cottonseed meal to two to three parts of 16 per cent acid phosphate drilled in the rows at the rate of 500 to 600 pounds per acre.

To prevent injury from burning, the fertilizer should be applied a week to ten days before planting. In very poor lands, or where level culture is practiced, the fertilizer should be applied broadcast and at a high rate. In the better lands, and where the plants are set in beds on ridges, it is usually applied in the row with a one- or two-horse fertilizer sower.

It has seemed to be the general belief of both growers and horticulturists that potash is very essential in the production of sweet potatoes. It is the belief of the author that this was often over-estimated and more potash was used than the crop could utilize. This is substantiated by Duggar and Williamson (16), who found that phosphate and nitrogen were much more important than potash, as is shown in Table 6.

TABLE 6

Fertilizer Experiment with Sweet Potatoes

Plot No.	Amount Fertilizer per Acre	Kind of Fertilizer	1912			1913			1914			Average, 3 Years	
			Yield Sweet Potatoes per Acre	Increase Over Unfertilized Plot	Profit from Fertilizer	Yield Sweet Potatoes per Acre	Increase Over Unfertilized Plot	Profit from Fertilizer	Yield Sweet Potatoes per Acre	Increase Over Unfertilized Plot	Profit from Fertilizer	Increase Over Unfertilized Plot	Profit from Fertilizer
	Pounds		Bushels	Bushels		Bushels	Bushels		Bushels	Bushels		Bushels	
1	400	Cottonseed meal...	141.1	1.7	$ 4.98	395.7	118.6	$65.16	401.4	119.4	$65.64	79.9	$41.94
2	480	Acid phosphate....	210.3	70.9	39.18	354.3	77.2	42.96	360.0	78.0	43.44	75.4	41.86
3		No fertilizer.......	139.4	.....	.....	277.1	.....	.....	282.0				
4	400	Kainit............	185.4	41.7	22.22	377.1	80.3	45.38	384.6	84.8	48.08	68.9	38.56
5	400	Cottonseed meal...											
	480	Acid phosphate....	225.4	77.4	37.08	440.0	123.6	64.80	454.3	136.7	72.66	112.6	58.18
6	400	Cottonseed meal...											
	400	Kainit............	198.6	46.3	18.98	404.9	68.8	32.48	417.1	81.8	40.28	69.0	30.58
		No fertilizer.......	156.6	.....	.....	355.7	.....	.....	353.1				
8	480	Acid phosphate....											
	400	Kainit............	226.6	61.9	30.98	445.7	67.2	34.16	458.3	83.2	43.76	70.8	36.30
	400	Cottonseed meal...											
9	480	Acid phosphate....	243.7	70.9	30.38	518.5	117.2	58.16	545.7	148.7	77.06	112.3	55.20
	400	Kainit............											
	400	Cottonseed meal...											
10	480	Acid phosphate....	273.7	92.9	44.98	527.1	103.0	51.04	532.0	113.0	57.04	103.0	51.02
	200	Kainit............											
11		No fertilizer.......	188.9	.....	.....	446.9	.....	.....	440.9				
	480	Acid phosphate....											
12	400	Kainit............	250.6	61.7	26.26	574.3	127.4	65.68	608.6	167.7	89.86	118.9	60.60
	200	Nitrate of soda....											

From Table 7 it is seen that nitrogen and phosphoric acid brought about equal average increases.

TABLE 7

Increase in Bushels of Sweet Potatoes per Acre Due to an Application of 400 Pounds of Cottonseed Meal, or 480 Pounds Acid Phosphate, or 400 Pounds Kainit

	1912	1913	1914	*Average increase 3 Years*
Increase of sweet potatoes per acre when cottonseed meal was added:				
To unfertilized plot	1.7	118.6	119.4	79.9
To acid phosphate plot	6.5	46.4	58.7	37.2
To kainit plot	4.6	−11.5	− 3.0	− 3.3
To acid phosphate and kainit plot	9.0	50.0	65.5	41.5
Average increase with cottonseed meal	5.5	50.9	60.2	38.9
Increase of sweet potatoes per acre when acid phosphate was added:				
To unfertilized plot	70.9	77.2	78.0	75.4
To cottonseed meal plot	75.7	5.0	17.3	32.7
To kainit plot	20.2	−13.1	− 1.6	1.8
To cottonseed meal and kainit plot	24.6	48.4	66.9	46.6
Average increase with acid phosphate	47.8	29.4	40.2	39.1
Increase of sweet potatoes per acre when kainit was added:				
To unfertilized plot	41.7	80.3	84.8	68.9
To cottonseed meal plot	44.6	−49.8	−37.6	−14.3
To acid phosphate plot	− 9.0	−10.0	5.2	− 4.6
To cottonseed meal and acid phosphate plot	− 6.5	− 6.4	12.0	− 0.3
Average increase with kainit	17.7	3.5	16.1	12.4

Kainit at the rate of 400 pounds per acre had little or no effect in increasing the yield when used with other fertilizers, though when used alone it increased the yield almost as much as cottonseed meal or acid phosphate. However, before these figures are universally adopted, more experiments are necessary in all the sweet potato states of both North and South to determine the true value, if any, of potash in the production of this crop.

While fertilizers exert a beneficial effect in increasing production, it fluctuates in some years more than in others. This is clearly shown from the work of Stuckey (93).

The area devoted to this experiment which was conducted from 1908 to 1913, inclusive, was divided into six plats of one-thirtieth of an acre each. The variety used was the Pumpkin Yam. The fertilizer treatments were as indicated in Table 8, which also gives the relative yields, and the subsequent effect of the fertilizers on the amount of rots in storage.

TABLE 8

Yields from Fertilizer Plots of Sweet Potatoes from 1908 to 1913

* Plot No. and Kind of Fertilizer Used	Yields per Plot			Bushels per Acre	Per Cent Rot During Winter
	Pounds Marketable Potatoes	Pounds Small Potatoes	Pounds Total		
			1908		
1	267	25	292	159.2	16.0
2	336	21	357	194.7	26.5
3	333	25	358	195.2	4.5
4	286	28	314	171.2	11.5
5	342	28	370	201.8	11.0
6	332	33	365	199.0	6.0

TABLE 8—*Continued*

* Plot No. and Kind of Fertilizer Used	Yields per Plot			Bushels per Acre	Per Cent Rot During Winter
	Pounds Marketable Potatoes	Pounds Small Potatoes	Pounds Total		
1909					
1	211	71	282	153.8	8.5
2	233	57	290	158.1	19.2
3	240	75	315	171.8	11.1
4	145	53	198	108.0	5.1
5	271	75	346	188.7	8.8
6	251	68	319	174.0	8.5
1910					
1	205	71	276	150.5	17.6
2	235	53	288	157.0	14.4
3	253	60	313	170.7	12.4
4	145	67	212	115.6	9.4
5	281	90	371	202.3	15.3
6	250	84	334	182.1	5.8
1911					
1	226	101	327	178.3	38.8
2	224	55	279	152.1	29.0
3	220	56	276	150.5	31.1
4	147	84	231	126.0	41.2
5	235	105	340	185.4	36.7
6	178	73	251	136.9	14.1
1912					
1	248	138	386	210.5	16.0
2	212	59	271	147.8	7.7
3	202	54	256	139.6	9.0
4	171	79	250	136.3	13.9
5	195	108	303	165.2	10.9
6	166	68	234	127.6	12.2

TABLE 8—*Continued*

* Plot No. and Kind of Fertilizer Used	*Yields per Plot*			*Bushels per Acre*	*Per Cent Rot During Winter*
	Pounds Marketable Potatoes	*Pounds Small Potatoes*	*Pounds Total*		
			1913		
1	322	129	451	246.0	15.8
2	359	66	425	231.8	32.5
3	270	76	346	188.7	32.5
4	187	94	281	153.2	19.1
5	307	122	429	234.0	17.5
6	307	75	382	208.3	38.3

FERTILIZER PER ACRE

*
1.......... 24 tons stable manure
2.......... 2100 pounds 16 per cent phosphoric acid
3.......... 900 pounds sulphate of potash
4.......... 1500 pounds nitrate of soda
5.......... 1800 pounds complete fertilizer
6.......... check, no fertilizer

It is seen from the foregoing table that with the exception of 1913, there was a gradual decline in yields in all plats from 1908 to 1912, irrespective of fertilizers applied. In 1913 there was a sudden rise in yield. This may perhaps be due to climatic variations from year to year. These data definitely show that no reliable conclusions can be drawn from one or two years' trials with fertilizers. It is further shown in Table 8 that the percentage of rot from the different plats varied from year to year to such an extent that it could not be said with certainty that the keeping qualities of sweet potatoes were in any way influenced by the kind of fertilizer used.

For poor soils, Duggar recommends the following formulas of fertilizers, the particular choice of which will depend mainly on the land itself. These formulas are shown in Table 9 and are self-explanatory:

TABLE 9

Fertilizer Formulas for Sweet Potatoes

Kind and Amount of Fertilizer per Acre		*Nitrogen*	*Available Phosphoric Acid*	*Potash*
	I	*Pounds*	*Pounds*	*Pounds*
150 pounds of nitrate of soda 350 pounds superphosphate 150 pounds muriate of potash		24	41	77
280 pounds dried blood 320 pounds boneblack 160 pounds muriate of potash	II	29	53	82
100 pounds nitrate of soda 160 pounds boneblack 80 pounds sulphate of potash 10 tons barnyard manure	III	114	27	113
360 pounds cottonseed meal 320 pounds superphosphate 640 pounds kainit	IV	26	43	94

STABLE MANURE

To thrive well, sweet potatoes require plenty of humus in the soil. This is often supplied by the application of stable manure or compost. Fresh manure should never be applied direct during the preparation of the land for planting. This will increase the expense of weeding, and in dry seasons the plants will suffer from drought. The manure should be applied to the previous crop as is practiced in New Jersey, where it is broadcasted in the fall, and applied at the rate of 10 to 15 tons per acre. Manure should not be used on lands affected with soil stain (*Monilochaetes infuscans*), or with pox, also known as ground rot (*Cystospora batata*). Numerous growers are in the habit of combining horse manure with chemical fertilizers. Table 10 by Price shows that the net gain from the combination of small quantities of the manure and chemicals was only $5.36 per acre. Twenty tons of manure per acre both alone and in combination with full quantities of chemical fertilizer, though increasing the yield, resulted in a considerable loss. However, these figures could mean but little because the experiment was run only two years, and perhaps on soils not responsive to treatment.

TABLE 10

Value of Crop from Different Fertilizers

	Cost of Fertilizer	*Net Value of Crop per Acre*	*Net Gain or Loss*	*Average Net Gain or Loss for Two Years*
No fertilizer	....	$113.33		
Manure and chemicals, one-half	$26.17	$118.69	$ 5.36 gain	$20.02 gain
Manure and chemicals, whole	$52.34	$92.43	$20.90 loss	$ 2.44 loss
Manure alone	$40.00	$106.76	$ 6.57 loss	$ 1.00 loss

Green Manure

Where manure is scarce, the soil humus may be secured through the use of green cover crops. Legumes, such as crimson clover, cowpeas, soy beans, vetch, and velvet beans, will make ideal green manures when worked under. In the northern sweet potato states, crimson clover is sown between corn rows at the last cultivation. The clover usually makes a good growth early in the spring and is plowed under when the land is prepared for sweet potatoes. In those parts of the Southern States where crimson clover does not thrive, velvet beans, cowpeas, or rye will give good results.

Lime or Hardwood Ashes

The use of lime on sweet potato soil is largely determined by the grower's own inclinations. On poor soils, or where green manure tends to sour the soil, the application of lime will be beneficial. Lime should be used indirectly, and preferably in a three-year rotation at the rate of one to two thousand pounds of burned lime per acre. It is best applied after plowing under a green crop, or to the crop preceding sweet potatoes. Burned lime should at first be air slacked.

Hardwood ashes are scarce and difficult to secure. When easily available, unleached wood ashes applied broadcast at the rate of 1200 to 1500 pounds per acre may take the place of lime. In no case, however, should either lime or wood ashes be applied to soil infected with pox. Where this is done, the disease greatly increases and the yields are reduced.

Effect of Fertilizers on Vine Growth

It is generally believed that the use of certain fertilizers will produce more vine growth in proportion to the yield of potatoes. Table 11 by Stuckey (93) shows

Table 11

Effect of Fertilizer on Vine Growth

Plat No.	*Fertilizer Used*	*Pounds Green Vines*	*Pounds Potatoes*
1	Stable manure	1226	451
2	Acid phosphate	422	425
3	Sulphate of potash	282	346
4	Nitrate of soda	716	381
5	Complete fertilizer	661	429
6	Check, no fertilizer	226	382

that stable manure alone gave a heavy crop of vines and a heavy crop of potatoes. The nitrate of soda gave a heavy crop of vines but a light crop of potatoes.

Effect of Fertilizers on Composition of Sweet Potatoes

To determine the effect of fertilizer on the chemical composition of the sweet potato at harvesting, Stuckey (93) carried out the experiments as indicated in Table 12. For treatment of plats 1, 2, 3, 4, 5, and 6, see p. 52.

TABLE 12

Effect of Fertilizer on Chemical Composition

1909	Plat 1	Plat 2	Plat 3	Plat 4	Plat 5	Plat 6
Water	65.72	65.83	64.32	66.81	69.10	64.50
Protein	1.62	1.71	2.05	1.52	1.46	1.95
Fat	0.39	0.38	0.41	0.37	0.36	0.44
Fiber	2.00	1.85	2.10	1.20	1.10	2.10
Ash	1.12	1.14	1.21	1.10	1.00	1.20
Sugar (sucrose)	5.46	5.50	6.25	5.75	4.60	6.15
Other carbohydrates	23.60	23.59	23.66	23.25	22.38	23.66
	100.00	100.00	100.00	100.00	100.00	100.00

1910	Plat 1	Plat 2	Plat 3	Plat 4	Plat 5	Plat 6
Water	70.3	71.2	70.8	72.4	70.6	70.8
Protein	1.5	1.4	1.5	1.3	1.6	1.7
Fat	0.6	0.5	0.6	0.5	0.8	0.8
Crude fiber	4.1	3.8	3.9	3.2	3.1	3.0
Ash	1.4	1.2	1.3	1.1	1.4	1.3
*Carbohydrates	22.1	21.9	21.9	21.5	22.5	22.4
	100.00	100.00	100.00	100.00	100.00	100.00
*Sugar	8.0	7.6	8.2	8.5	9.1	8.9

1911	Plat 1	Plat 2	Plat 3	Plat 4	Plat 5	Plat 6
Water	63.55	65.30	68.40	68.15	65.45	66.20
Protein	1.70	1.85	1.30	1.20	1.45	1.35
Fat	0.45	0.50	0.40	0.50	0.48	0.45
Sucrose	5.45	7.30	6.20	5.15	5.35	5.60
Dextrine	4.85	6.25	5.30	5.10	5.15	4.90
Starch	21.63	16.25	15.25	17.13	18.87	18.32
Fiber	1.00	1.10	1.55	1.35	1.75	1.80
Ash	1.37	1.45	1.60	1.42	1.50	1.35
	100.00	100.00	100.00	100.00	100.00	100.00
Reduced to Dry Basis						
Sucrose	14.95	21.04	19.62	16.17	15.48	16.56

Table 12—(*Continued*)

1912

	Plat 1	*Plat 2*	*Plat 3*	*Plat 4*	*Plat 5*	*Plat 6*
Water	68.30	65.92	68.75	69.40	70.10	68.30
Fat	0.34	0.32	0.34	0.35	0.36	0.34
Protein	1.70	1.75	1.65	1.60	1.52	1.72
Fiber	2.10	2.00	1.95	1.90	1.85	2.05
Ash	1.19	1.30	1.30	1.15	1.10	1.28
*Carbohydrates	26.37	28.71	26.01	25.60	25.07	26.31
	100.00	100.00	100.00	100.00	100.00	100.00
*Sugar	5.75	5.10	6.15	6.05	4.90	5.20

1913

	Plat 1	*Plat 2*	*Plat 3*	*Plat 4*	*Plat 5*	*Plat 6*
Water	60.02	60.46	66.24	72.65	71.50	73.70
Protein	1.11	0.38	0.52	0.37	0.41	0.62
Fat	0.18	0.21	0.31	0.17	0.18	0.18
Sucrose	2.47	2.65	2.76	2.48	2.50	2.24
Starch	21.00	21.66	23.90	19.22	22.51	18.09
Crude fiber	0.63	0.58	1.35	0.65	0.64	0.71

From the foregoing table it is seen that there is not sufficient constancy in the chemical composition of the roots, due to the application of various fertilizers to justify the statement that chemical composition is affected by fertilizers. However, from other data it seems that an excess of nitrogen produces a lighter yellow flesh, with an insipid flavor, and a soggy, soft texture when baked. This seems to be the case especially with the Pumpkin Yam, when heavily fertilized with nitrate of soda. However, quality seems to go hand in hand with applications of acid phosphate, or a complete fertilizer.

Cultivation

As soon as the plants are well rooted, cultivation should begin. It is poor practice to allow the weeds to get the best of the grower. A few days after planting, a sweep or a one-horse plow should be run in the middle to loosen up the strip of earth left in ridging. All cultivation should be of a shallow nature, and this is especially necessary after a rain or irrigation. As far as possible all cultivation should be done by horse and cultivator, and the hand labor reduced to one or two hoeings. Some soils are very weedy and a third hand hoeing may be necessary. The cost of hoeing and cultivation has been estimated by Garcia (24) in New Mexico at $5.60 per acre during the season. This amount will, of course, vary in different states.

A two-horse riding cultivator answers in the cultivation of sweet potatoes. It is more desirable when the cultivator has discs instead of hoes, as it can also be used for throwing the soil towards the rows. For laying by, growers frequently use a single-row, celery hiller, or a one-horse sweep stock which can be fitted with sloping boards. Some growers use a small one-horse turn plow for the final cultivation, going twice in each alley and working the soil toward the plants.

Irrigation

The sweet potato can stand considerable drought, however, there is a limit beyond which it will actually burn up. Such a condition was experienced in many parts of Texas during the summers of 1917 and 1918. Wherever possible, irrigation should be resorted to during prolonged dry spells. In New Mexico, especially in the southern part of the state, irrigation of sweet potatoes is practiced extensively. It is not uncommon there to give six to ten irrigations during the season. In New Mexico, Garcia (24) claims that when the surface soil is kept moist the potatoes are not formed deep, but are made nearer to the surface of the ground. This is also true in other states, since droughty conditions force the roots to go deep for their moisture, thus making the harvesting very difficult.

Effect of Pinching off Vines

In case of heavy vine growth, some growers make it a practice to cut off a large number of vines in order to force down all food to the roots. Frequently, also, sweet potato vines are cut back and fed green to hogs. To determine the effect of this practice on the final yield, Stuckey (93) made some preliminary tests. In 1912 six rows 200 feet long were well fertilized and planted with the variety Enormous, early in May. By June 14 the vines had completely covered the soil. Rows 1, 2, 5, and 6 were cut back to one foot in length, and the cut vines removed from the field. A few weeks later these had grown out again and covered the soil. On October 24th the potatoes were harvested with the results as seen in Table 13.

Table 13

Effect of Cutting Back Vines on Yield

Rows 1 and 2	680 pounds
Rows 3 and 4	1062 pounds
Rows 5 and 6	620 pounds

From Table 13 it is seen that cutting back the vines reduces the yields.

Cost of Production.

The cost of producing an acre of sweet potatoes will, of course, depend on the region where grown and methods of culture. Because of the great difference in cost of labor, rent of land, cost of growing plants, fertilizers, storage, and marketing facilities, no definite statement can be made to hold for every condition. Miller (69) gives the following items of cost of production per acre in some of the eastern sweet potato sections:

1. Rent of land	$ 5.00
2. 10,000 plants at $1.00 per thousand	10.00
3. Fertilizer	15.00
4. Setting plants with tongs	1.25
5. Cultivation	3.00
6. Harvesting a 100-barrel yield, picking up potatoes at 15 cents per barrel	15.00
7. 100 barrels at 25 cents each	25.00
Total cost per acre	$74.25

This does not include the cost of hauling to market. In some parts of the South the cost of producing an acre of sweet potatoes will not exceed $40.00 to $50.00.

The average price received for sweet potatoes during 1920 was $2.50 to $3.00 per barrel. At this rate $100.00 to $200.00 is often realized from an acre of sweet potatoes. Success with sweet potatoes from a financial standpoint depends on crop rotation, which increases yield, reduces the cost of fertilizer, and keeps down disease. Good storage houses, and a knowledge of the best marketing conditions will also help to make the sweet potato crop profitable.

Yield

The yield per acre will depend on the season, the amount of rainfall, the soil, the fertilizer used, the time of digging, and the variety. Varieties which are best for table purposes, seldom produce as much as those which are less desirable. Although it is not uncommon to obtain yields ranging from 200 to 700 bushels to the acre, yet on an average, 200 bushels per acre is considered satisfactory. Varieties grown for stock food are very heavy yielders. Among these may be mentioned the Providence, Hayman, Norton, Peabody, Red Bermuda, Shanghai, Southern Queen, Nigger Choker, and Pumpkin Yam.

That the yield is influenced by the time of digging was shown by Stuckey (93), who in 1911 planted the Golden Beauty and Enormous. These were harvested as shown in Table 14.

Table 14

Yield Affected by Time of Digging

Variety	*Date of Harvest*	*Yield per Acre*	*Price per Bushel*	*Value of Crop*
Golden Beauty.......	Sept. 11	65.7 bu.	$1.25	$82.125
Golden Beauty.......	Nov. 11	348.4 bu.	0.75	261.30
Enormous..........	Sept. 11	177.2 bu.	1.25	221.50
Enormous..........	Nov. 11	255.8 bu.	0.75	191.85

It is seen that early digging was, in the case of Golden Beauty, less remunerative than late digging, although the price per bushel was higher. This was due to an enormous loss from decrease in yield.

CHAPTER IV

VARIETIES

It is unfortunate that the names of the different varieties of sweet potatoes are badly confused. The same variety may have many names under different growers and in various localities. The variety "Big Stem Jersey," for instance, parades under fifty names in some of the sweet potato states. Growers seem to vie with each other as to who will present to the buyer of plants more new varieties (really old varieties with changed names). The same confusion exists in the literature. Horticulturists in the various Experiment Stations have been slow to develop a system of classifying sweet potatoes. The common variety, Southern Queen, has been so variously described by different workers, that it leads one to believe that few of the workers dealt with that variety.

The sweet potato constitutes a staple food crop. Before any headway may be made on the breeding and improvement of this crop it is essential to devise a uniform system of classification, so as to standardize all varieties and eliminate all the confusion in nomenclature.

Price (78) was the first to devise a system of classification based on the shape of the leaves, which is as follows:

a. Foliage Round or Entire. This includes the Up

River, Big Stem Jersey, Pumpkin, Shanghai, Norton, Hayman, and Southern Queen.

b. Foliage Shouldered. This includes the Gold Skin, Delaware, Extra Early, Caroline, Early Golden, Yellow Jersey, Brazilian, Red Bermuda, Red Nose, New Jersey, Yellow Nansemond, Negro Choker, Red Nansemond, Red Bermuda, and Peabody.

c. Foliage Lobed. This includes Barbados, Sugar (Creole), Yellow Yam, Vineless (Bunch Yam, Early Bunch Yam), Spanish Yam, Georgia, and Tennessee.

In the United States few workers seem to have adopted Price's system of classification. However, this system was adopted by Robson (84) in his description of West Indian varieties.

A key, based on shape of foliage alone, is very inadequate. The same vine will often have half a dozen variously shaped leaves. To classify sweet potatoes as to shape, size, color, or quality of tuber is also a hopeless task.

In the adoption of a key, the distinguishing characters must be reasonably permanent. The abundance of latex and the color of leaves in sweet potatoes are not constant enough to be reliable. It is to the credit of Dr. Groth (26) to have worked out the best key so far known; hence it is adopted by the author because of the following reasons:

1. It is a key and a classification combined. All varieties are determined by the same characters and can be readily compared, while in the ordinary key each variety is thrown out at an opportune moment by a character which may be common to many others already separated by some other character. One comes to associate that particular character with that variety, while in reality it depends entirely on the arbitrary arrange-

ment of the key whether the character is used at all. Similarly there is very little attempt made in the arrangement of the ordinary key to keep together the varieties, resembling each other, while in this key they stand together naturally. For example, Bronze Spanish, as the name indicates, has a peculiarly colored tuber. In the ordinary key this character would very probably be used at an earlier stage to separate it. Black Spanish has a tuber which is similar to several others, and it would be hard to separate it by that character. Yet the two can not be told apart in the field, unless one digs for the tubers.

2. It can be used with incomplete specimens. If a certain character can not be determined from the material on hand, the space reserved for it may be left blank, and the next character taken up. One is not continually before alternatives which may be at the time unanswerable. It is likely that the determination is possible even without that character.

3. It is more convenient to the non-scientist. In the determination of all varieties the same process is gone through, and once that process is learned by heart it need not be changed again for the determination of the next variety.

4. It is flexible. The writer is certain that he has not studied all varieties existing. New varieties can be easily catalogued and inserted in the list by any one. In the ordinary key the advent of a variety necessarily causes confusion, as it not only could be wrongly determined, but would also interfere with the determination of other varieties which might agree with it in the critical characters. This would make an ordinary key useless, while this key provides for all. Should other characters be found which would aid in the determina-

tion, they could simply be entered under subsequent letters L, M, N, etc., without interfering in the least with the working of the key.

Groth's Key for Classifying Sweet Potatoes

A. Shape of leaf.
1. Cut.
2. Round.
3. Long.
4. Broad.
5. Mixed (round and lobed).

B. Size of leaf.
1. Small (less than 4 inches across).
2. Large (more than 4 inches across).

C. Length of stem.
1. Long (more than 4 feet long).
2. Short (less than 4 feet long).

D. Color of stem.
1. Green (with or without brownish areas).
2. Green, with purple around the axils of the leaves.
3. Greenish-brown to purple.
4. Purple.

E. Size of stem.
1. Thin (less than 1/8 inch in diameter).
2. Thick (more than 1/8 inch in diameter, often 3-16 or more).

F. Presence of star.
1. Star present.
2. Star absent.

G. Color of lower surface of veins.
1. Veins purple.
2. Midrib pinkish in some old leaves.
3. Purple spot at the base of the midrib.
4. Veins all green.

H. Arrangement of hair on upper surface of leaf.
1. Hair all over.

2. Chiefly on tip and along veins.
3. Absent.

I. Outside color of tubers.

1. White.
2. Yellow, golden or bronze.
3. Yellow-red or pinkish.
4. Red or purple.

J. Color of the flesh of the tubers.

1. White.
2. Cream-colored or yellowish-white.
3. Pinkish-white or pinkish-yellow.
4. Pink-orange.
5. Marked with purple.

K. Distinctness of wood elements in tuber.

1. Distinct.
2. Blurred.
3. Not visible.

How to Use the Key

The use of the key is very simple. Take an unknown plant or one that is parading under a false name to be determined. Let us suppose that its leaves are cut. This will put it in A1. The majority of the full-grown leaves are more than 4 inches across from tip to tip of the most spreading lobes. This will bring it in B2. Suppose the full-grown stems are shorter than four feet. This will put it in C2. As the stems are green with purple marks around the axil of the leaves, we have D2. The full-grown stems measure 3/16 of an inch at their thickest point—a characteristic indicated by E2. The purple star is clear and the lower surface of the vein is purple—characteristics indicated by F1 and G1. As a few of the younger leaves show a few scattered hairs on the midrib, and some of the older leaves have no hair at all, we express these facts by H2, 3. The roots we find to be white outside and inside, which means I1 and J1. The bundles, or wood elements, are not visible on the freshly cut surface. This fact is indicated by K3. Thus our formula runs: A1, B2, C2, D2, E2, F1, G1, H2, 3, I1, J1, K3. When we refer to the alphabetical arrangement of the formulas, we find that it is the formula of Ticotea. If all these points agree, we may be certain that the variety is Ticotea.

Latest Method of Classification

Perhaps the latest and most recent method of classifying sweet potatoes is that of Thompson,* who places all varieties in eight groups. A key to these groups follows:

KEY TO THE GROUPS

I. Leaves deeply lobed or parted—1 and 2.
- (1) Leaves with purple stain at the base of the leaf blades. TICOTEA.
- (2) Leaves without purple stain at the base of the leaf blades. BELMONT.

II. Leaves not deeply lobed or parted—1 and 2.
- (1) Leaves with purple stain at the base of the leaf blades—*A* and *B*.
  - (*A*) Stems purple or greenish with decided tinge....SPANISH.
  - (*B*) Stems—*a* and *b*.
    - (*a*) Leaves entirely to slightly shouldered; roots white. SHANGHAI.
    - (*b*) Leaves toothed with 6 to 10 low marginal teeth, or entire; roots salmon or yellow tinged with salmon. FLORIDA.
- (2) Leaves without purple stain at the base of the blade or with very faint stain—*A* and *B*.
  - (*A*) Stems purple......................SOUTHERN QUEEN.
  - (*B*) Stems green—*a* and *b*.
    - (*a*) Stems medium to large in size; roots fusiform, yellow tinged with salmon, with light yellow veins PUMPKIN.
    - (*b*) Stem slender; roots russet yellow or red, ovoid to fusiform ....JERSEY

* Thompson, J. C., and Beattie, J. H. "Group classification and varietal descriptions of American varieties of sweet potatoes." *U. S. Dept. of Agr. Bul.* No. 1021: 1–30, 1922. (*With bibliography.*)

The classification of the varieties in the eight groups is as follows:

Group	*Varieties Belonging to the Group*
TICOTEA	Ticotea, Koali
BELMONT	Belmont, Eclipse Sugar Yam, Vineless Pumpkin Yam, Old Time Yam, Yellow Yam, and White Scaly
BELMONT *Bunch section*	Gros Grandia, Bunch Candy Yam
SPANISH *Yellow Spanish section*	Pierson, Yellow Strasburg, Yellow Spanish, Triumph
SPANISH *Bermuda section*	Red Bermuda, Red Brazil, Porto Rico, Key West Yam, Creola
SPANISH *Red Spanish section*	Red Spanish, Purple Yam, or Nigger Choker, Dahomey
SHANGHAI	Shanghai, Minnet Yam
FLORIDA	Florida, General Grant, Vineless, Nancy Hall
SOUTHERN QUEEN	White Yam, Southern Queen
PUMPKIN	Pumpkin Yam, Norton, Dooley, White Gilke
JERSEY *Red Jersey section*	Japan Brown, Red Jersey
JERSEY *Big stem Jersey section*	Big Stem Jersey, Philipili
JERSEY *Yellow Jersey section*	Yellow Jersey, Gold Skin

CHAPTER V

HARVESTING

When sweet potatoes are dug for early market, maturity is no consideration. In this case the roots are dug just as soon as they are of marketable size. For this purpose, it is more economical to plant a definite acreage in early-maturing varieties that will be ready to be dug in August. For storage purpose, however, the crop must be harvested when it is well matured. Immature roots are very hard to keep. However, few agree as to what constitutes maturity. It is believed that a fully mature potato, when cut open, will soon dry and form a white hard crust on the cut surface, while an immature potato will bleed, and the cut surface will remain moist, thereby inviting the entrance of the germs which produce rots. Climate, rainfall, favorable growing season, soil, fertilizer, and variety used are all factors which influence early or late maturity. The tendency is to dig as late as possible, so as to increase the yield. This is safe enough in a comparatively dry fall. During excessive rainfall, which may occur late in the season, extra growth, although increasing the yield, will not be conducive to good keeping. Rapid growth before digging means roots gorged with moisture, and uneven development, which results in cracking of the matured roots. Sweet potatoes are very sensitive to cold. A light frost, when only slightly injuring the vines, may not hurt the roots; however, a heavy frost becomes dangerous. When the vines are killed by frost they should at once be cut off and the roots dug immediately. When the frost is very severe, and penetrates the tip ends of the potatoes, no attempt should be made to store them. Frost injured potatoes are poor keepers. They can be saved if disposed of for early consumption.

The ideal time to dig is during dry warm weather. Digging during wet spells should be avoided, as at that time bruising the potatoes in the field will encourage far more rapid rotting. Furthermore, during such weather the potatoes will naturally be more watery, and hence will require longer curing. If the season should be too wet and the grower is forced to dig, the potatoes will be put in the house wet and muddy. When such conditions prevail, the potatoes must be dried quickly. Such wet potatoes should not be stored in great bulk, but rather in various bins, in small quantities, or possibly they should be left in the hampers and kept for at least twenty-four hours in a dry shed, where the excessive moisture will have a chance to evaporate. It is not a good practice to dig the potatoes late in the evening and allow them to remain uncovered during the night, as they may be greatly injured by frost or by rain. Neither is it advisable to dig very early in the morning, when the ground is more or less cool and the vines damp with dew. The best time to dig is after the sun is well up and until 3 or 4 in the afternoon, or only until such time that the grower will be able to pick up all that he has dug that day. It is never advisable to allow the dug potatoes to remain exposed too long to the sun, although a few hours' exposure, when the outdoor temperature is 75 to 80 degrees F., will be beneficial, as it will help to dry the roots. Should the weather be very hot, too long exposure to the sun will blister the potatoes and cause them to rot in storage.

The investigations of Hasselbring (54 and 55) shed considerable light on the question of maturity in regard to harvesting. It is evident that marked changes occur in the roots the latter part of the season; hence the time of harvesting will largely depend on the purpose for which the sweet potatoes are intended, namely, stock feed, silage, or the manufacture of starch. In the latter case, harvesting should be done when the starch content is at its maximum. According to Hasselbring, the composition of the roots during the latter part of the growing season seems to remain remarkably uniform, presenting no striking or irregular fluctuations. At this time the roots in the soil contain their maximum amount of starch with the minimum amount of sugar. As soon as the vines begin to dry, water immediately accumulates in the roots as a result of cessation of transpiration. Because of the destruction of leaves the transformation of carbohydrates, that is, the change of starch into sugar, which is so characteristic of sweet potatoes in storage, begins to take place in the field. Reducing sugar is formed first as an intermediate step in the change from starch to cane sugar. It is evident from this, that on no account should harvesting of sweet potatoes be delayed after the leaves have been killed by frost.

Implements for Harvesting

On small areas, and for home use, sweet potatoes may be dug with a spading fork. On a large scale, plows designed for that purpose are used. In eastern Virginia, a vine cutter is run over the rows in order to cut the vines first, and the roots are then thrown out with an ordinary turning plow. This system is not satisfactory, as the turn plow bruises the roots. Frequently an ordinary disc harrow is used to cut the vines, and all but two of the discs are removed. Such an arrangement works well in cutting off the vines. However, the discs often sink deep in the soil, and bruise the roots. Machines used for digging Irish potatoes are not suitable for harvesting sweet potatoes, as they bruise and otherwise injure them. A good type of digger is a plow with rolling coulters on the beam to cut the vines, and with rods attached to the moldboard to free the roots from the soil and vines. Another type of digger is also shown in Fig. 1c. Both these kinds of plows loosen the hills of potatoes without disturbing the ground around them. The potatoes then must be scratched out. This is done by taking hold of the stem end of the hill and firmly pulling the roots which cling to the main stem out of the soil. A small jerk and shake will detach and free all the potatoes from that hill. Here care is necessary since careless helpers will often use force in shaking the hill and thus violently throw the roots on the ground and bruise them badly. To facilitate grading in the field and filling the hampers, potatoes from three to four rows are placed together. This is easily done when four "scratchers" are instructed to put their potatoes in one row. Potatoes once gathered in the hampers or containers should not be allowed to remain exposed in the field because of danger of overheating. Overheated potatoes will not cool off so rapidly in storage and hence will rot before early curing is completed.

Finally, during digging, scratching, and grading, every reasonable precaution should be taken to avoid bruising the sweet potatoes. It is true that many bruised potatoes keep well and do not rot, but it is equally true that a large percentage of the rotting begins at the place of a cut or bruise. Frequently wounded sweet potatoes heal over by forming a layer of starch free cells beneath the injured surface. This naturally tends to ward off infection. Weimer (112) has found that wounds heal over under storage conditions of 33 degrees C. and a relatively high humidity.

Grading

Sweet potatoes are generally sorted into two grades, primes and culls. These grades are based on size; all culls include the small and stringy potatoes. Frequently a third grade or "extra prime" is made, and this consists of extra choice potatoes, uniform in size, regular in shape and free from cracks and diseased spots. Finally a fourth grade is often made, which includes all the extra large ones or "Jumbos."

To save time and labor, it is best to grade in the field during harvesting. A desirable plan is to go over the rows and pick up all seed potatoes first, then the marketable roots, and finally all bruised ones and culls, which are stored separately or used for stock feed. The following are the grades suggested by the United States Department of Agriculture, Bureau of Markets, Department Circular 99, 1920:

United States Grades for Sweet Potatoes

U. S. Grade No. 1

U. S. Grade No. 1 shall consist of sound sweet potatoes of similar varietal characteristics which are practically free from dirt or other foreign matter, frost injury, decay, bruises, cuts, scars, cracks, and damage caused by heat, disease, insects (including weevils), or mechanical or other means.

The diameter of each sweet potato shall not be less than one and three-quarter inches nor more than three and one-half inches, and the length shall not be less than four inches nor more than ten inches, but the length may be less than four inches if the diameter is two and one-quarter inches or more.

In order to allow for variations incident to commercial grading and handling, five per cent, by weight, of any lot may not meet the requirements as to diameter and length, and, in addition, six per cent, by weight, may be below the remaining requirements of the grade.

Any lot in which the diameter is not less than one and one-half inches and which contains a greater percentage by weight of sweet potatoes below one and three-quarters inches than is permitted in U. S. Grade No. 1, but which otherwise meets the requirements of such grade shall be designated as U. S. Grade No. 1 Medium.

Any lot in which the length is not less than six inches nor more than twelve inches and which contains a greater percentage by weight of sweet potatoes above ten inches in length than is permitted in U. S. Grade No. 1, but which otherwise meets the requirements of such grade shall be designated as U. S. Grade No. 1 Long.

U. S. Grade No. 2

U. S. Grade No. 2 shall consist of sound sweet potatoes of similar varietal characteristics, not meeting the requirements of the foregoing grades, which are free from serious damage caused by dirt or other foreign matter, frost injury, decay, bruises, cuts, scars, cracks, heat, disease, insects, or mechanical or other means, and which are not less than one and one-half inches nor more than three and one-half inches in diameter.

In order to allow for variations incident to commercial grading and handling, five per cent by weight of any lot may not meet the requirements as to diameter, and, in addition, six per cent by weight may be below the remaining requirements of this grade.

U. S. Jumbo Grade

U. S. Jumbo Grade shall consist of sound sweet potatoes of similar varietal characteristics, which are free from serious damage caused by dirt or other foreign matter, frost injury, decay, bruises, cuts, scars, cracks, heat, disease, insects, or mechanical or other means, and which are not less than three and one-half inches in diameter.

In order to allow for variations incident to commercial grading and handling, five per cent by weight of any lot may be less than the diameter prescribed, and, in addition, six per cent by weight may be below the remaining requirements of this grade.

U. S. Grade No. 3

U. S. Grade No. 3 shall consist of sweet potatoes not meeting the requirements of any of the foregoing grades.

Definition of Grade Terms as Used in These Grades

"Practically free" means that the appearance shall not be injured to an extent readily apparent upon casual examination of the lot, and that any damage from the causes mentioned can be removed without appreciable increase in waste over that which would occur if the sweet potatoes were perfect.

"Diameter" means the greatest dimension at right angles to any portion of a central line running through the sweet potato from stem end to root end.

"Free from serious damage" means that any damage from the causes mentioned can be removed without increase in waste of more than ten per cent by weight over that which would occur if the sweet potatoes were perfect.

Hauling

After the potatoes have been properly graded and either crated or placed in hampers they should be hauled to the storage house. The containers should be filled full and tightly covered to prevent jolting. They should then be placed on a spring wagon and the smoothest road preferred for hauling. This is done to prevent every unnecessary jar. If a spring wagon is not available, the jarring may be overcome to a certain degree by placing a good layer of hay or straw on the bottom of the wagon. There are also springs made for temporary insertion in farm wagons.

Whenever possible, the storage house should be situated near the center of production, to shorten the haul and cause less damage to the potatoes. On no occasion should potatoes be dumped into the wagon and carried to the house. Neither should they be filled into sacks and laid on the wagon to be taken to storage. It is very common for growers to ship several carloads or sometimes their entire crop to some far distant town to be stored. This is permissible if the purchaser knowingly buys such a product, for he takes the risk of losing a large part of the crop from rots. For best results and economy, sweet potatoes should never be shipped long distances by rail or water, for storage. Under these circumstances it is safer to sell the crop early than to attempt to store it. The best practice requires building a storage house at the time the acreage is decided upon.

CHAPTER VI

USES OF THE SWEET POTATO

THE sweet potato, if properly developed, can be utilized commercially in more than one way.

AS A FOOD

In the South the sweet potato is depended upon as one of the staple crops. In the Northern, Eastern, and Western states its edible qualities are being recognized more and more. In the South, under ordinary cropping systems, corn usually yields twenty bushels per acre.

TABLE 15

Analyses of Various Feeding Stuffs Compared with the Sweet Potato

Crop	*Per Cent. Water*	*Per Cent. Ash*	*Per Cent. Protein*	*Per Cent. Crude Fiber*	*Per Cent. Nitrogen Free Extract*	*Per Cent. Ether Extract*
Irish potato	78.9	1.0	2.1	0.6	17.3	0.1
Beets, common	88.5	1.0	1.5	0.9	8.0	0.1
Turnips	90.5	0.8	1.1	1.2	6.2	0.2
Ruta-bagas	88.6	1.2	1.2	1.3	7.5	0.2
Carrots	88.6	1.0	1.1	1.3	7.6	0.4
Parsnips	88.3	0.7	1.6	1.0	10.2	0.2
Artichokes	79.5	1.0	2.6	0.8	15.9	0.2
Sweet potato	68.1	1.0	1.6	0.9	27.9	0.5
Corn	10.6	1.5	10.3	2.2	70.4	5.0

With sweet potatoes the yields vary from one hundred to two hundred bushels per acre, furnishing nearly three times the food value corn does. Tables 15 and 16 by Keitt (58) compare the feeding value of various vegetable crops with that of the sweet potato.

TABLE 16

Yield and Feeding Stuff Analyses of the Different Varieties of Sweet Potatoes

Variety	*Yield Bushels*	*Per Cent. Water*	*Per Cent. Protein*	*Per Cent. Fat*	*Per Cent. Fiber*	*Per Cent. Ash*	*Per Cent. Nitrogen Free Extract*
Nancy Hall........	270.0	68.75	1.75	0.60	1.00	0.89	27.01
Polo..............	281.0	72.53	1.52	0.33	0.78	1.09	23.75
Southern Queen....	416.0	68.38	1.52	0.47	0.74	1.08	27.81
White Spanish.....	141.0	67.27	1.48	0.45	0.73	0.89	29.18
General Grant.....	191.0	66.52	1.34	0.74	0.82	0.79	29.79
Brazilian..........	450.0	65.45	1.65	0.56	1.00	1.10	30.24
Arkansas Beauty...	158.0	72.80	1.66	0.49	0.96	1.09	23.00
Tennessee Notchleaf	281.0	68.87	1.50	0.51	1.05	1.04	27.03
Yellow Nancemond.	214.0	72.12	1.33	0.50	1.09	1.00	23.96
Purple Yam.......	180.0	65.67	1.83	0.33	1.01	1.19	29.97
Pumpkin Early Yellow Yam........	270.0	62.20	2.18	0.65	0.97	1.11	32.89
Shanghor Yam.....	174.0	65.82	1.15	0.31	0.66	0.82	31.24
Vineland Bunch Yam	141.0	69.84	1.45	0.50	0.73	0.70	26.78
Fulleton Yellow Yam	326.0	67.74	1.77	0.37	0.79	0.83	28.50
Average.......	250.0	68.1	1.6	0.5	0.9	1.0	27.9

In general the chemical composition of sweet potatoes resembles that of the Irish potato. The former, however, contains on an average about 9 per cent less water and 9 per cent more carbohydrates than the Irish potato. This is shown in Table 17 by Langworthy (59).

TABLE 17

Average Chemical Composition of Sweet and Irish Potatoes

Kind of Potato	Refuse	Water	Protein	Fat	Carbohydrates: Sugar, Starch, etc.	Carbohydrates: Crude Fiber	Ash	Fule Value per Pound
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Calories
Sweet potato (edible portion)	....	69.0	1.8	0.7	26.1	1.3	1.1	560
Sweet potato (as purchased)	20.0	55.2	1.4	0.6	21.0	...	0.9	450
Sweet potato (cooked)	....	51.9	3.0	2.1	42.1	...	0.9	905
Sweet potato (canned)	....	55.2	1.9	0.4	40.6	0.8	1.1	800
White potato for comparison (edible portion)	....	78.3	2.2	0.1	18.0	0.4	1.0	375
White potato for comparison (as purchased)	20.0	62.6	1.8	0.1	14.7	...	0.8	305

Although containing less protein than the Irish potato, the sweet potato has a larger proportion of available protein, estimated at about 13 per cent. The proportion of sugar and starch varies with the varieties. Those grown in New Jersey, Maryland, and Delaware, for instance, are rich in starch. The Southern varieties on the other hand contain a larger per cent of sugar. The proportion of total sweet potato discarded with the skin as waste is about 20 per cent, the same as for the Irish potato.

Cooking Recipes

The reason sweet potatoes are not more generally used is that few people except perhaps those in the South know how to cook them. Sweet potatoes can be prepared in more than one way and indeed our liking for this delicious root crop will depend a great deal on how it is prepared for the table. The delicate flavor of the sweet potato is frequently lost through poor cooking. Steaming preserves the flavor better than boiling, and baking still more than steaming. The sweet potato, when cooked hurriedly, is tasteless. A short-time baking, for instance, may satisfy a hungry man but when flavor is desired, longer cooking or baking should be resorted to. The following are various recipes taken from Parloa (77), Carver (9) and Fitz (23) and slightly modified by Mrs. A. H. Leidigh of College Station, Texas.

1. *Baked Potatoes.* Wash the potatoes with a brush in running water until thoroughly clean. They are then baked like white potatoes without breaking the skin. When done, the potato is cut in half, buttered and served hot. As a rule, however, baking seems to be better adapted to the larger round and irregular sweet potatoes. Small potatoes will bake in about half an hour where very large ones will require an hour or more. If potatoes are liked moist and sweet, they should be baked one to two hours, the exact length of time depending on their size.

2. *Baked in Ashes.* With this method the sweetness

and taste of the sweet potato is brought out in an unusual manner. The potatoes are merely covered with warm ashes to a depth of four inches, upon which live coals and embers are maintained. Baking is done slowly for at least two hours. The ashes are then removed with a soft brush and the potatoes are served with hot butter.

3. *Boiled or Steamed Sweet Potatoes.* Sweet potatoes are boiled or steamed in the same way as Irish potatoes and without breaking the skins. When boiling is practical, the water is poured off as soon as done and the potatoes are left in the pot, covered with a plate, and placed on the back of the range until served. In this way, however, the cooked sweet potato will be soggy. A better way is to cover the cooked roots with a cloth for a few minutes before serving.

4. *Browned.* Medium-sized sweet potatoes are boiled for forty minutes. They are then peeled and cut lengthwise into halves. These are placed in a baking pan and basted in savory drippings and seasoned with salt. They are cooked in a hot oven for twenty minutes.

5. *Fried.* The potatoes are cut lengthwise into slices and fried in deep grease in the same way as are Irish potatoes, care being taken not to have them fried too hard and dry.

6. *Candied Sweet Potatoes.* This mode of preparing sweet potatoes is very popular in the South. Candied potatoes are very palatable when well prepared. They are boiled first and cut into long slices, which are placed in an earthen dish. On each slice is put a lump of butter and a sprinkling of sugar. Some prefer to add a little water. It is placed in the oven and baked until the sugar and butter have candied and the potatoes become browned.

7. *Chips.* Potatoes are cut into thin slices, and steamed until nearly done. The surplus water is drained off and the steamed potatoes are dried between napkins. Fry in deep grease to a light brown. A little salt is added. This makes a delicious breakfast dish.

8. *Sweet Potato Pie No. 1.*

1 pt. cooked sweet potato pulp
½ pt. milk
½ pt. cream
4 eggs, well beaten
1½ cups sugar
Ginger, cinnamon and cloves to taste

Boil potatoes in skins. When tender peel, mash, and beat until light. Add other ingredients and bake with bottom crust only. This makes five or six pies. Spices may be omitted or less sugar may be used if desired.

9. *Pie No. 2.* The following recipe given by Fitz is from Arkansas and is as follows:

1 qt. boiled strained potato pulp
3 eggs
3 tablespoons sugar
1 tablespoon butter
Lemon peel or essence of lemon
½ nutmeg grated
½ teaspoon cinnamon
¼ teaspoon cloves

Add cream or milk to make a mixture the consistency of butter. This is poured into a baking plate and baked with two crusts.

10. *Sliced Potato Pie.*

Sweet potatoes
Butter size of hen's egg (¼ cup)
1 cup sugar
½ cup molasses
1 cup cream
Flour (a little)
Hot water
All-spice, ginger, cloves and nutmeg

Line deep baking dish with rich pastry. Boil sweet potatoes until two-thirds done, remove skins, and slice very thin lengthwise. Fill the dish to a depth of 2 inches. Add other ingredients, and enough hot water to cover. Put on upper crust and crumple edge. Bake in moderate oven until done and serve hot, with or without sauce.

11. *Glazed No. 1.* Medium-sized sweet potatoes are boiled and cut into halves. These are laid evenly in a braising pan, basted with syrup and butter warmed together, and sprinkled lightly with brown sugar. The whole is put in a hot oven until brown and served with syrup.

12. *Glazed No. 2.* Potatoes are cut in slices one-half inch thick, washed, and placed in a deep sauce-pan. They are spread with butter and seasoned with a little grated nutmeg and salt, and moistened with broth or water. The pan is then covered and allowed to simmer over a slow fire for three-fourths of an hour. Turn the slices so that they are glazed on both sides. They are served with drawn butter or other sauce.

13. *Sweet Potato Cobbler.* The potatoes are prepared in the same way as for No. 8. The dish is then filled in the same way as for layer cake, rolling out a layer of dough quite thin and then spreading the mixture in layers about one-fourth of an inch thick. This is done until the dish is full. To each layer is added just enough water to cook the layer of crust. The whole is baked until thoroughly done and served hot with drawn butter or hard sauce.

14. *Sweet Potato with Roast Beef No. 1.* The beef is roasted and a brown gravy made. Medium-sized baked potatoes are then peeled and served on the dish with the roast.

15. *Sweet Potatoes with Roast Beef No. 2.* The desired number of sweet potatoes are parboiled until nearly done. They are then moved from the fire and

peeled and laid in a baking dish with the nearly done roast, and cooked until done and then served with the beef.

16. *Sweet Potato with Roast Lamb.* A desirable piece of fresh lamb is selected and baked until nearly done. Some of the grease is poured off. The potatoes are prepared in the same way as for No. 15. They are laid in the gravy and slightly browned with the meat until done.

17. *Broiled.* Sweet potatoes are steamed, pared, and cut in slices three-eighths of an inch thick. The slices are laid in a double broiler, salted, covered with melted butter, and broiled over a slow fire. Serve hot in folded napkins.

18. *Stuffed No. 1.* The potatoes are baked, one end is cut off, and the inside removed. This pulp is then seasoned with butter, pepper and salt, and beaten until light and filled into the skins, which are closed with the cut-off piece, and put into the oven to heat through. Serve in napkins. These are suitable for luncheon.

19. *Stuffed No. 2.* This is prepared the same way as No. 18. Add to every pint of potato ½ cup of minced meat and mix thoroughly. Fill the skins, heat, and serve.

20. *Southern Dish.* Cut baked sweet potatoes into slices and put into an earthen dish. To each layer are added sugar and butter and the whole is baked until slightly brown.

21. *Croquettes.* To two cupfuls of mashed, boiled, steamed or baked sweet potatoes, the beaten yolks of two eggs are added and the whole is seasoned to taste. This is stirred over the fire until the mass separates from the pan. When cold it is formed into small croquettes, rolled in egg and bread crumbs, and fried in

hot grease until of an amber color. They are served in napkins.

22. *Sweet Potato Balls.* These are prepared in the same way as croquettes; they are made into balls with minced meat in the center.

23. *Purée.* Boiled, steamed, or baked sweet potatoes are mashed and seasoned; enough hot milk is then added to moisten. They are then served like mashed, white potatoes. They may also be put in a pudding dish and top-dressed with egg. After they have browned in an oven, they are then served with sauce.

24. *Browned.* Cold boiled, or steamed sweet potatoes are cut into slices one-fourth of an inch thick. Add butter, sugar, pepper and salt, and put in a hot oven to brown.

25. *Scalloped Sweet Potatoes.* The potatoes are washed, peeled, and sliced very thin. They are then put in layers in a baking dish and each layer seasoned with salt, butter, one-half teacup of sugar, a dash of spice, nutmeg, and ginger and covered with equal parts of milk and cream. This is baked in a moderate oven until tender and then served hot.

26. *Browned.* Small-sized potatoes are washed and pared. They are then steamed or boiled until they can be readily pricked with a fork. The surplus water is then dried off and the potatoes rolled in a dish with melted butter and placed in a quick oven until slightly browned. They are then served hot.

27. *Hashed Potatoes.* Cold potatoes steamed, boiled, roasted, or baked, are cut into small pieces and placed in a well-buttered pan. Stir in minced scraps of meat of any kind. This is allowed to brown and is then served hot. Chicken is the most excellent meat to put in it.

28. *Baked with Apples.*

4 medium-sized potatoes
4 apples
1½ cups sugar
½ cup butter
1½ cups hot water

Wash and peel the potatoes and apples and cut in ¼-inch slices. Put into a baking dish in alternate layers, sprinkling each with butter and sugar. Add water and bake slowly for an hour and serve steaming hot.

29. *Sweet Potato Pudding.*

2 cups mashed boiled sweet potatoes
1 cup sugar
1 cup butter
4 eggs
Pinch of soda dissolved in 1 teaspoon water
1 cup cream
1 teaspoon cinnamon
1 grated nutmeg
1 teaspoon lemon extract

To the hot potato pulp, add sugar, creamed butter, eggs beaten light, and other ingredients. Bake in a deep plate lined with puff paste, using a moderate oven. When done, the top is covered with slices of fruit marmalade and sprinkled thickly with granulated sugar.

Sweet Potato Syrup. The feasibility of making syrup from sweet potatoes was demonstrated by the Bureau of Chemistry (6) of the United States Department of Agriculture. The syrup is claimed to be palatable and wholesome. The method was developed by a specialist of the Bureau of Chemistry and is only recommended on a small scale, as it could not compete with syrups made on a commercial basis from grains. The sweet potato syrup has a consistency, taste, and color similar to cane and sorghum syrups.

The Method in Brief. The sweet potatoes should be washed, any decayed portions or other blemishes removed, and weighed. They are then placed in a kettle with plenty of water and boiled until thoroughly soft. One and one-half to two hours are required. The potatoes are then mashed in the kettle in the water in which they were boiled. More water should be added, if necessary, to form a thick, smooth, mushy liquid. The temperature of the mixture is then brought to 140 degrees F., and a quantity of ground malt added, equal to 3½ per cent of the weight of the original sweet potatoes. The mixture is thoroughly stirred and allowed to stand for a few minutes at a temperature of 140 degrees F., and with constant stirring raised to 150 degrees F. The source of heat is then removed, and the mass allowed to stand with occasional stirring for an hour. The mixture known technically as the "mash" is now pressed in cloth to separate the liquid and solid portions. The material is placed in a closed cloth bag, and the bag subjected to gentle pressure while being kneaded. The juice flows out readily, leaving the pulp behind. The juice is now boiled down to syrup in an ordinary kettle.

Any of the common varieties of sweet potatoes can be used. Freshly harvested stock will yield a syrup somewhat less sweet than sweet potatoes which have been harvested for some time.

The sweet potatoes should be cooked with plenty of water. It is necessary to obtain a fluid, mushy mass, which can be mixed readily with the malt.

Great care must be taken that the temperature of the mass be uniform throughout during the action of the malt.

Preparation of Malt. Ordinary brewer's or distiller's malt of good quality gives excellent results, or the malt can be made by sprouting barley under proper conditions. In the preparation of malt from barley the following method will give satisfactory results: The grain should be soaked in water for twelve hours. The water is then drained off and the grain allowed to stand for twelve hours, and the operation of soaking and standing repeated during the next twenty-four hours. At the conclusion of the steeping, the interior of the grain is then spread upon a tray in a layer not over six or eight inches deep. The temperature at which the sprouting grain is kept is of great importance in the successful manufacture of malt. It should be kept as near 60 degrees F. as possible. After the grain has grown for six or eight days the sprout forces its way out of the end of the grain opposite to the rootlet, and the malt may be used with excellent results at this time. Sprouting, however, may be allowed to continue slowly for another six or eight days, or even longer, until the sprout has attained a length three to four times that of the grain. The grain must be kept moist, so that the rootlets do not wither during the sprouting period and should be turned over and thoroughly mixed at least once a day and kept covered with a wet cloth and in the dark. The product is known as "green malt." It should have a fresh odor and be free from any sour smell, and should be free from mold. Immediately before use, the green malt should be ground finely in an ordinary meat chopper or other suitable machine. When so ground it forms a pasty mass and may be added directly to the boiled mashed sweet potatoes and the mixture thoroughly stirred.

Separating the Liquor. On a small scale this is most readily accomplished as described. On a large scale an ordinary cider press, using racks and cloths, can be successfully employed. The liquor obtained is slightly sweet and rather turbid. Plenty of water should be used in order to produce a mash from which the liquor will flow freely and in which a large proportion of the sugar may be easily removed by a single pressing. The total quantity of water used should be two or three times the weight of the potatoes. The sweet-potato syrup can be boiled down to as thick a consistency as desired. The pulp which remains can be dried and used for feed, or it can be fed to cattle while fresh.

Not only is the sweet potato a valuable food for humans, but it can also serve a similar purpose for stock. Varieties, such as Enormous and Nigger Choker, are high yielders and could be grown as stock feed.

Sweet Potato Vines for Forage

If it were not for the great expense in harvesting sweet potato vines they would make an excellent forage or hay, which is greatly relished by stock. Table 18 by Keitt (58) gives the composition of the vines of four varieties of sweet potatoes.

Table 18

Composition of Sweet Potato Vines

Name of Variety	*Protein*	*Fat*	*Fiber*	*Ash*	*Nitrogen Free Extract*	*Total*
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Brazilian...........	12.30	5.15	17.10	9.78	55.67	100.00
Polo...............	14.28	4.88	17.98	9.06	53.80	100.00
Southern Queen.....	11.28	4.34	18.70	8.04	57.64	100.00
Nancy Hall.........	12.07	5.05	19.11	8.03	55.74	100.00
Average........	*12.48*	*.4.86*	*18.22*	*8.37*	*55.71*	*100.00*

On account of the expense of gathering the vines, they are more profitably plowed under, and serve as a valuable source of humus in the soil.

Sweet Potato Silage

It has been previously stated that the sweet potato could be used as a stock food. The work of Scott (86) has shown that it can be more profitably grown as stock feed. Sweet potatoes were first put in the silo of the Florida Experiment Station in 1917. Analysis of corn and sweet potato silage is as follows:

Silage	*Moisture*	*Crude Protein*	*Nitrogen Free Extract*	*Fiber*	*Fat*	*Ash*
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Sweet potato.....	54.87	1.82	39.41	1.48	0.66	1.85
Corn............	73.7	2.1	15.4	9.3	0.8	1.7

From the above figures it is evident that there is but little difference in the feeding value of the two. But, 100 pounds of sweet potato silage will replace 150 to 200 pounds of corn silage in the ration. This is due to the fact that sweet potato silage contains less water and two and a half times more nitrogen-free extract than the corn silage.

To determine the milk production from sweet potato and sorghum silage, Scott made the following tests (May 9 to June 20), lasting forty-three days. The test was made in two periods of twenty days each with three days between periods for the purpose of changing feed. Ten cows were used and divided into two lots of five each. Each cow in Lots I and II was given the following daily ration as shown in Table 19.

TABLE 19

Lot I	*Pounds*	*Lot II*	*Pounds*
Wheat bran	8.4	Wheat bran	8.4
Cottonseed meal	2.8	Cottonseed meal	2.8
Sweet potato silage	10.6	Sorghum silage	15.2

During the second period the feeds were reversed, that is, the cows in Lot I were given the feed of Lot II, and Lot II the feed of Lot I. Cows fed on sweet potato silage produced 307.1 gallons of milk. Cows fed on sorghum silage produced 280.9 gallons of milk; a difference of 26.2 gallons in favor of the sweet potato silage. The feed used in the above experiment was charged as follows: wheat bran $40.00, cottonseed meal $50.00, corn silage $4.00, and sweet potato silage $13.33 a ton. At this rate the feed cost of a gallon of milk produced by the corn silage ration was 11.8 cents, by sweet potato silage 14.2 cents. The difference, however, in cost of production, was due to the high price charged to the sweet potato silage. Sweet potato silage saves considerable storage space and dispenses with all losses from rots.

SWEET POTATO STARCH

The sweet potato as a starch crop has received but little attention. During the Civil War, a small amount of impure starch was made in the Southern States. McDonnell (66) was practically the first to consider the manufacture of sweet potato starch on a commercial basis. Starch is greatly in demand by the cotton manufacturers, and it is used in "sizing" yarn and in "filling cloth." The product generally used is either Irish potato or corn starch. All the high-yielding varieties of sweet potatoes which are poor for table purpose could be grown as starch producers.

Process of Manufacture. The machinery used for the manufacture of starch from Irish potatoes may also be adapted for the same purpose for sweet potatoes. On a large scale, the potatoes are first run through a washer and all dirt and sand removed (Fig. 5, a). From the washer they are carried and dumped into a hopper, or pulping machine (Fig. 5, b). The thin pulp coming from the pulping machine is made to fall on an inclined sieve (Fig. 5, i.) of fine wire gauze, having eighty meshes to the inch. Above the sieve, water is thrown on the pulp, which separates the small starch granules and washes them through the sieve (Fig. 6, i.). The white starchy liquid falls from the sieve into a tank, and from there is pumped into settling tanks. These are about fifty feet in diameter and eighty feet deep. After a few hours' standing, the starch settles down, and the dirty colored water is siphoned off. The starch is then transferred to washing tanks, where it is washed several times in fresh water, which is siphoned off after the starch has settled. The purified material is then transferred in trays to dry kilns (Fig. 5, j.) and left there until the moisture has been reduced to ten or twelve per cent. The dry kiln is heated by steam coils, which do away with the danger of fire. The temperature during drying should never be higher than 150 degrees F. When the dried starch has been removed from the kiln, it is piled up in warehouses in order that the moisture may be evenly distributed through the mass. It is then

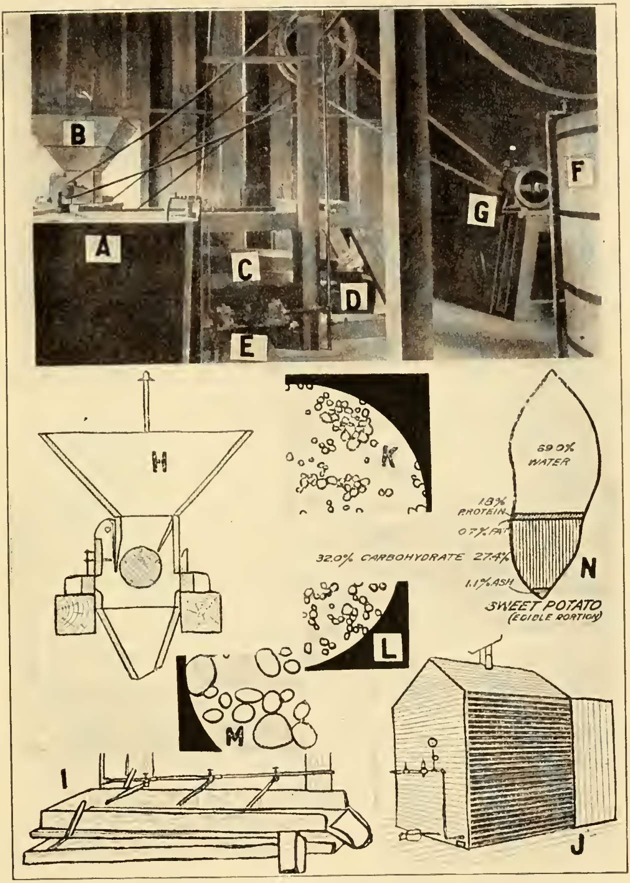

FIG. 5. SWEET POTATO STARCH FACTORY.

A. Tank for washing potatoes. *B*. Pulping machine. *C*. Starch separator. *D*. Receptacle for starch milk. *E*. Steam pipe. *F*. Starch washing tank. *G*. Motor. *H*. Pulper. *I*. Sieve. *J*. Drying house. *K*. Sweet potato starch grains. *L*. Corn starch grains. *M*. Irish potato starch grains. (*A* to *M*, after McDonnell). *N*. Diagram illustrating composition of sweet potato (after Langworthy).

barreled and ready for market. Table 20 by McDonnell (66) shows the amount of starch obtained per bushel from Southern Queen and Red Nancemond.

TABLE 20

Amount of Starch from Different Varieties

Variety	*Quantity Operated Upon*	*Total Starch in Potatoes*	*Total Starch Re-covered, Com-mercial*	*Starch Remain-ing in Pulp*	*Starch Lost in Wash Water, etc.*	*Total Weight Dried Pulp*
	Bushels	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Southern Queen..	26	321.6	184.0	111.8	41.5	182.0
Southern Queen..	17	224.7	154.0	78.3	6.6	121.8
Red Nancemond..	13	127.3	80.0	43.3	8.5	84.0
Providence......	8.2	104.1	76.0	17.1	22.6	32.8
Southern Queen..	12.5	161.0	100.0	31.7	43.3	57.0
Triumph........	15	202.8	137.0	42.3	47.8	75.0

Starch from the sweet potato, like that of the Irish potato, may be bleached with sulphur dioxide, sulphurous acid, or bleaching powder and sodium hypo-sulphite. It is also often treated with dilute alkalies, sodium hydrate, or lime water to dissolve the gums and all other impurities.

Sweet potato starch grains slightly resemble the grains of corn starch (Fig. 5, l.). They are, however, more variable in size and not so angular. The hilum is well developed, and is cross- or star-shaped (see comparisons of Figs 5, k.).

USES FOR SWEET POTATO STARCH

For the laundry, sweet potato starch is ideal. It makes a paste quickly. Three-quarters of a pound goes as far as a pound of the laundry starch from corn or Irish potatoes (Fig. 5, m). It also penetrates the goods much better. It does not adhere to the surface of starched collars or cuffs. The starched articles do not adhere to the rollers when surface starch is not wiped off. The finished laundry does not crack when bent. Sweet potato starch is also admirably adapted for sizing yarns, filling cloth, and thickening colors, in cotton mills and print shops.

TABLE 21

Showing Calculated Yield per Acre, Per Cent. Glucose, Sucrose, Starch, Total Fermentable Carbohydrates and Yield Calculated from the Carbohydrates of Gallons of Alcohol per Acre

Variety	*Rate of Yield per Acre in Bushels*	*Per Cent. Glucose*	*Per Cent. Sucrose*	*Per Cent. Starch*	*Per Cent. Fermentable Carbohydrates*	*Theoretical Yield in Gallons of Alcohol per Acre*
Nancy Hall	270.0	1.53	2.35	17.82	21.70	292.1
Polo	281.0	1.75	2.02	14.85	18.62	260.0
Southern Queen	416.0	1.51	2.18	19.07	22.76	473.5
White Spanish	141.0	0.55	3.36	20.05	23.96	169.5
General Grant	191.0	0.31	4.09	17.30	21.70	207.5
Brazilian	450.0	1.22	2.89	16.46	20.57	262.2
Arkansas Beauty	158.0	1.78	3.25	14.43	18.64	152.7
Tennessee Notchleaf	281.0	2.00	2.38	16.71	21.09	295.1
Yellow Nancemond	214.0	1.36	3.78	13.50	18.64	198.1
Purple Yam	180.0	1.44	2.18	19.40	23.02	207.4
Pumpkin Early Yellow Yam	270.0	1.69	3.66	20.63	25.98	343.6
Shanghor Yam	174.0	0.49	2.77	23.89	27.15	181.1
Vineland Bunch Yam	141.0	1.83	3.23	19.22	24.28	167.6
Fulleton Yellow Yam	326.0	0.52	3.36	18.72	22.60	369.3

The by-product of sweet potato starch is the pulp. This can be used as a feed for stock, or for making alcohol. One bushel of pulp would yield about one-half gallon of 95 per cent alcohol. This should be looked to in the future as an important source of fuel in the various industries. Table 21 by Keitt (58) is very suggestive of the amount of starch and alcohol to be obtained from the total of varieties.

Location of Starch Factories

The essential requirements in the location of starch factories are as follows:

1. Factory should be located near source of supplies. Sweet potatoes are very bulky and do not stand long shipment.
2. A good water supply free from suspended organic matter, algae, salts, and iron.
3. Cheap transportation facilities, both rail and water.
4. Factory should be located on or near a stream to dispose of the waste water.
5. Dependable labor and markets.

Owing to the growth of the textile enterprise, sweet potato starch should find there its best home markets.

PART II

DISEASES

CHAPTER VII

MORPHOLOGY OF THE HEALTHY HOST

To gain a clear understanding of the diseases of the sweet potato, and especially of the effect of parasite on host, it is necessary to study the structure of the healthy plant. The author has devoted considerable study to this phase, and his observations practically agree with the studies made by Groth (26).

The root. By root is here meant the edible portion of the sweet potato. The latter is not a tuber, as is often stated in literature, but is a thickened root, fascicular to spherical, veiny or smooth, 3 to 6 lobed in cross-section. The root lenticels are either conspicuous or very small; the dormant shoots are situated near the lenticels. The shoots appear first at the tip end, but later come out irregularly from every direction. The color of the edible roots is white, yellowish to pinkish-white, or bronze, light to dark purple, flesh, cream-colored, pinkish-white, pinkish-orange. The cambium and wood elements are white, dirty white, yellow, or orange, distinct or indistinct. The flesh is soft or hard.

When a thin cross section of a young rootlet is placed under a microscope, the xylem is found to be very prominent, usually arranged in five patches, and separated as it were by medullary rays.

In a cross section of an edible root, the xylem element appears in groups or isolated, each surrounded by actively growing tissue in the midst of fundamental tissue. The cells in both growing and fundamental tissues are gorged with compound starch grains. The cambium element is situated outwardly towards the epidermis, with the ring of xylem either radiating towards the center or not. Frequently five or more groups of xylem element run in strands outside of the cambium layer, forming longitudinal ridges known as veins.

The stem. The stem or vine growth varies from twenty feet or more in some varieties to about two feet in the bunch varieties. Its diameter varies from ⅛ to more than ¼ inch at its largest parts. In some varieties fasciation is a common occurrence; in others the vines strongly twine, run, or grow in clumps. The color varies from light green throughout to dark purple all over, with gradations of purple below the attachment of the petioles. Lenticels are abundant; hairs are present in young shoots and may be persistent. New roots may develop on each joint on the two opposite sides of the stem. With a long favorable season these roots may develop into small or medium-sized potatoes.

A microscopical study of a cross-section of the tip of a stem will reveal numerous glands on the epidermis. Hairs are also present and their abundance depends on the variety. Epidermal cells are thin-walled. The one or two layers of hypodermis are always well marked. The cortex is loose with intercellular spaces and contains well-marked milk or latex canals, each of which is composed of four to six secreting cells. The endodermis is sharply marked, and below is an interrupted one-to-three-celled layer of very thin-walled pericambium. The xylem is well developed. The internal phloem consists of small isolated patches of dividing cells among pith cells smaller than the rest. The pith also contains latex canals and large cells with intercel-

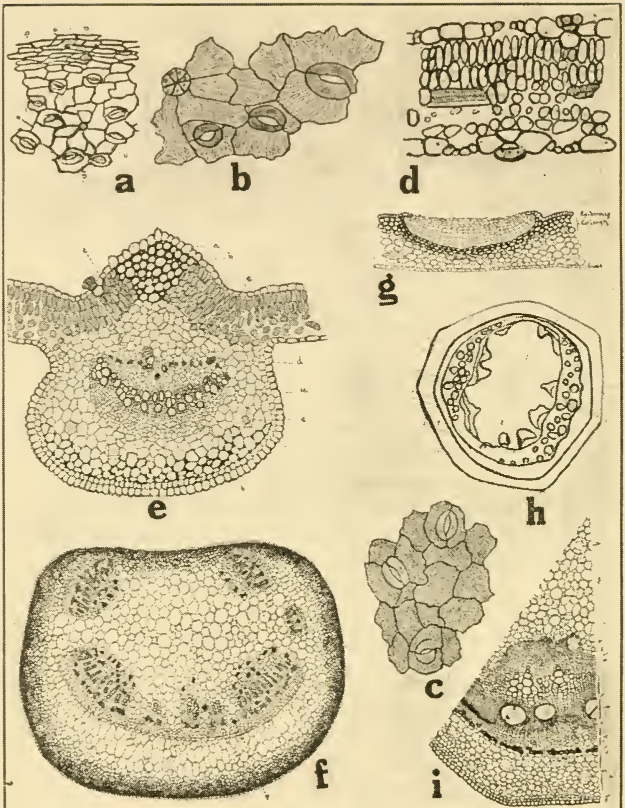

FIG. 6. MORPHOLOGY OF HEALTHY HOST.

a, *b*, and *c*. Surface view of epidermis showing arrangement of stomata. *d*. Cross-section through sweet potato leaf. *e*. Cross-section through sweet potato leaf vein. *f*. Cross-section through leaf petiole. *g*. Lenticel or proliferation of the epidermis of old stem of Georgia. *h*. Diagram of cross-section of base of stem of Florida. *i*. Cross-section of old stem of Southern Queen. (*a* to *i* after Groth.)

lular spaces. Few or no crystals are evident in the young tips.

At the base of an old stem, the epidermis contains few gland cells, and bears few or no hairs but has numerous lenticels. The epidermal cells are thin-walled and the hypodermis is more prominent and has no or few crystal cells. The collenchyma sheath is composed of three to five outer layers of cortex. The latex or milk canals are either flattened or well preserved. The secreting cells are either well preserved or they have disappeared. The endodermis is well marked. The pericambium is composed of a ring of strongly thickened fibers in some varieties and of thin fibers in others. The phloem is unevenly distributed in thickness with or without crystals and occasionally with a few latex canals. The cambium is strongly marked, the xylem wide or narrow, sometimes without or with vessels which, when present, are filled with tyloses. The xylem cells show spiral and reticulated thickenings as well as bordered pits. Xylem cells are not lignified uniformly, the crystal cells occurring in the unlignified cells. The protoxylem is divided from the cambium of the internal phloem by patches of narrow areas similar to fundamental tissue but with cells smaller than the cells of the pith. The fundamental tissue is of large thin-walled cells with large intercellular spaces and many latex canals. The pith cells are connected by pore plates, and are often divided into chambers, the latter of which contain crystals (Fig. 6, h and i).

Leaf. Normally developed leaves vary in different varieties, from 2½ to 6 inches or more in their widest diameter. The veins are palm-like in arrangement.

Microscopically the epidermis of the leaf consists of irregularly shaped, sinuate, thin-walled cells, convex towards the outer surface, and modified in shape when elongated over bundle traces, or radiating from gland cells, or surrounding base of hairs, showing peculiar wall striations. The stomata are located on both surfaces (Fig. 6, a, b and c) being more abundant on the lower side of the leaf. The stomata often show successive divisions of surrounding cells and guard cells, and sometimes double guard cell formation. The gland hairs are scattered over both surfaces of the leaf. The mesophyll consists of two to three layers of palisade parenchyma with stomatic chambers in which may be very thin-walled cells containing calcium oxolate crystals (Fig. 6, d and e).

Petiole. Petiolar nectraries consist of invaginations of the epidermis, forming cavities thickly lined with glandular hairs. There are many latex canals in the pith of the petiole tissue. Crystal cells are formed in the fundamental tissue near the bundles and in the phloem (Fig. 6, f).

CHAPTER VIII

LOSSES FROM SWEET POTATO DISEASES

THE object in growing any crop is to produce as much feed and food and to clear as much reasonable net profit as possible. The drawbacks in farming are poor soils, unfavorable climatic conditions, and plant diseases. In the United States we have sufficient good soils, and reasonably dependable weather conditions in the sweet potato regions to produce a profitable crop. On an average, and especially under present conditions, prices are good, and the demand for sweet potatoes is equally so. The only drawback, therefore, is the numerous diseases which cut down the yields in the field and affect keeping in storage.

These losses are caused by several diseases, the principal ones being: Black Rot, Stem Wilt, Ground Rot, also known as "pox" or "pit," White Rust, Septoria Leaf Spot, Soft Rot, Charcoal Rot, and Dry Rot.

The estimate of losses in the United States in 1917 from stem rot (*Fusarium hyperoxysporum* and *F. batatatis*), black rot (*Ceratostomella fimbriata*), and storage rots caused by various organisms are shown in Table 22.*

* From Plant Disease Bulletin 2 : 1–17, 1918.

TABLE 22

Field and Storage Losses

State	Production, 1917, Bushels (000 Omitted)	Reduction in Yields Due to Disease					
		Stem Rot		Black Rot		Storage Rots	
		Per Cent.	Bushels (000 Omitted)	Per Cent.	Bushels (000 Omitted)	Per Cent.	Bushels (000 Omitted)
New Jersey	2,880	10	320	5	152	20	720
Pennsylvania	110	0	0	2	2	0	0
Delaware	560	5	29	5	29	15	99
Maryland	1,180	5	62	8	103	15	208
Virginia	4,160	3	129	4	173	15	734
West Virginia	280	0	0	2	6	0	0
North Carolina	8,550	2	174	7	644	30	3,664
South Carolina	7,600	2	155	7	572	30	3,257
Georgia	11,625	2	237	5	612	30	4,982
Florida	3,500	2.5	90	1	35	1	35
Ohio	95	2	2	2	2	0	0
Indiana	318	0	0	2	6	0	0
Illinois	776	2	16	4	32	5	41
Iowa	270	5	14	5	14	0	0
Missouri	896	1	9	2	19	0	0
Kansas	368	2.5	9	2.5	9	10	41
Kentucky	1,140	0	0	0	0	25	380
Tennessee	2,850	0	0	15	503	25	950
Alabama	16,020	2	327	8	1393	30	6,865
Mississippi	5,525	2	113	8	480	30	2,368
Louisiana	4,898	0	0	4	204	30	2,099
Texas	6,552	1	66	5	345	30	2,808
Oklahoma	1,350	2	28	4	56	30	578
Arkansas	4,400	2	90	3	136	30	1,886
New Mexico	236	0	0	10	26	0	0
California	1,002	2	20	6	64	0	0
United States	87,141	1.47	1890	4.36	5617	24.6	31,715
Other diseases, United States	.....	..	.....	..	.....	1.94	2,484
Total loss due to disease, United States	.....	..	.....	..	.....	32.37	41,706

The foregoing figures are very conservative and speak for themselves. From this is apparent the importance of reducing these losses, so as to increase the nation's food, and at the same time insure a more profitable production. This can be done by the grower making a study of his business and by giving careful attention to the diseases which cause these losses. The various sweet potato troubles will be presented in detailed form, and the causal organisms arranged somewhat in their botanical order (mycological).

Pox, or Pit (Soil Rot)

Caused by *Cystospora batata,* Elliot

Economic Importance. Next to the black rot (*Ceratostamella fimbriata*), and stem rot (*Fusarium botatatis* and *F. hyperoxysporium*), pox, or pit, may be considered an important and serious disease of the sweet potato. Until recently the trouble was misunderstood, being frequently mistaken for black rot. For this reason the exact distribution of this disease and the money losses caused by it are not definitely known.

Pox is undoubtedly of great economic importance, but estimates of the money losses from the trouble can not be given for all the States where sweet potatoes are grown. It may be safely stated that in fields where pox has become thoroughly established, the yields may be reduced by about 50 to 80 per cent. The writer has had occasion to make such estimates in many sweet potato fields in Delaware, New Jersey, Maryland and Virginia.

Geographic Distribution. There seems no doubt that pox has a wider geographical distribution than is at present known. It can probably be found wherever sweet potatoes grow. In New Jersey, Halsted recorded it as a very serious, well-distributed disease. In Delaware it is as yet localized in Kent County, but appears to be gradually spreading southward. In Virginia the pox, although widespread, is at present localized in small areas. In Maryland the disease was recorded by Townsend (107) and was found by the writer to be a serious trouble, vying in importance with black rot. In South Carolina pox was reported by Barre (2). In Texas it had been previously reported by Price (79) and from the writer's own observation, pox is a serious disease in the State. The same trouble seems also to be prevalent in Alabama, where it was recorded by Wilcox (114) and in Oklahoma as reported by Learn (60). The disease is also prevalent in Kansas, Prof. L. E. Melchers having recently sent specimens of it to the writer.

Name of the Disease. The term "soil rot" given by Halsted (27) is appropriate only in so far as it indicates that infection takes place on the underground portion of the plant. It suggests practically nothing as to the nature or symptoms of the disease. In New Jersey the trouble is known to growers of sweet potatoes as "ground rot," a name not more suggestive than "soil rot." In Delaware the nature of the disease was only vaguely understood; hence, it was variously known as "bug sting," "worm hole," "fertilizer-burn," or often mistaken for black rot. In Texas the disease has no definite name, but it is variously confused with the many root troubles of the sweet potato. In Virginia the disease is known to growers as "pox," or "pit," which best describes the trouble, and which name was adopted first by the author (96) and later by Elliott (18).

Symptoms. In the literature, pox, or soil rot, is

FIG. 7. SWEET POTATO POX.

a. Sweet potato root badly disfigured by pox. *b*. Showing cracking of the pox spots just before they drop out. *c*. Young sweet potato roots attacked by pox. *d*. Sweet potato plant with rootlets destroyed by pox. *e*. Cysts of *Cystospora batata*. *f*. Young plasmodia (*e* and *f* after Elliott). *g*. Stages of *Cystospora batata* mistaken by Halsted for a fungus, *Acrocystis batatas* (after Halsted).

poorly described, the symptoms of the disease not being fully given. The author's extended field observations on the symptoms of pox may be summarized as follows: In badly affected fields the stand will be somewhat uneven. This, however, may not always be the case. That which attracts the attention most is thin growth, stunted vines, and a pale-green color of the foliage, all of which give the impression of a very impoverished soil. In fact, growers do not attribute these conditions to the disease, but to a lack of certain elements in the soil which past sweet potato crops have removed. Such claims are unfounded, as these soils seem to produce good crops of corn, watermelons, etc. In pulling out a sweet potato hill from a soil of this character one will be surprised to find almost no secondary feeding rootlets (Fig. 7, d). This is especially true when the examination is made at the season of maximum growth. Many of the feeding rootlets will be found totally destroyed, while others will exhibit numerous brownish spots at various intervals. Generally speaking, if infection starts at the tip of a growing root, the disease will work its way upward, and destroy it completely, leaving a discarded stub, which resembles the infected roots of other crops subject to the attacks of species of Thielavia. On the other hand, if infection takes place laterally, the resulting spot will be limited to about 1/10 inch (Fig. 7, b and c). Frequently such roots may exhibit 5 to 10 spots, each separated from the others by a healthy area. The color of the spot is a deep chocolate-brown. Such infected rootlets, it is needless to say, become functionless. Besides attacking the feeding rootlets, the pox also attacks the small roots which are destined to develop into edible roots (Fig. 7, c). This infection may be as severe and of the same character as in the feeding rootlets. Reduction in yield, lack of the normal green color, and limited vine growth may therefore be directly attributed to the destruction by the disease of the feeding rootlets and young roots.

Infection of the older growing roots may result in a constriction. Growth may seem to cease at this point, although it is uninterrupted on either side (Fig. 7, a). Infection of the older roots, besides misshaping them, does not, however, result in a total loss. Such roots usually attain a fair marketable size, and do not suffer in the least in edible quality. Here, however, the disease is manifested differently from that on the young rootlets. On the older roots infection may be of two types.

The normal and typical one is characterized by small, dry, darkish, circular, more or less superficial spots the size of a dime or smaller. Later, the tissue of the spot in most cases dries up, cracks (Fig. 7, b), and falls out, leaving a pox, or pit, whence the name of the disease. As a rule, a new skin is formed immediately below the area of the fallen spot. The depth of the spot seems to vary with the weather conditions; in dry weather the pox spots seem to enter more deeply into the tissue than during wet spells. In cases of light infection, there may be but 1 to 3 spots on the potato. In severe cases, however, the spots may be so numerous as to coalesce. The dead tissue of the spots when dropping out, leaves a large, ragged, irregular pit. The tissue of the pox spot is dry and leathery, but is readily pulverized when rubbed between the fingers.

The second form of infection of the older potatoes is what Elliott (19) terms "blister" infection. It was observed by the author but once, and in that case the infection took place at a feeding rootlet, then worked down to the main root, and was later apparent as a blister-like elevation on the epidermis.

Methods of Spread. It has already been stated that in dry weather the pox spot seems to be deeper than in wet weather. It is the general opinion of Halsted (27), Townsend (107), and Duggar (15), that pox is worse during dry weather. This in reality is true only in so far as the pox spots are deeper, and cause much more visible damage by distortion and disfigurement of the marketable roots. In wet weather pox is just as severe, and the causal organism perhaps more active, but the spots are shallower and less noticeable. The roots are not so disfigured, and, hence, are more saleable. According to Halsted (27) and others, pox is spread about from field to field by wind-blown spores of the causal organism. The work of the author does not seem to bear this out. Extended observations and studies have shown that pox does not spread readily by means of wind-blown spores from field to field or even to adjoining fields. If it did, the disease would spread very rapidly over large areas. This, however, is not the case. Pox will not become very noticeable until 8 or 10 years after its introduction in a field, and then only when the crop is continually grown on the same land. The disease does not seem to spread rapidly from an infected field to the neighboring field, but advances slowly, unnoticed and unsuspected. Definite evidence is also lacking as to whether pox is carried over on the small potatoes (seeds) in storage. As a rule, sweet potato growers never hesitate to plant infected stored seed. According to the author's observation, and numerous communications from growers, sprouts from such seed, when pulled for transplanting, have not shown evidences of pox on any of the underground portions of the plant.

This is further strengthened by Duggar (15), who states that "soil rot has not been observed to spread by way of the hot-bed, but only through contamination of the soil of the field." In order to verify this, the author has often planted infected seed which wintered over in storage in a sterilized soil. At no time, however, did the resulting sprouts show any marks of pox. The mode of spread of pox needs further careful investigation. It seems reasonable to suppose, however, that the disease is probably disseminated by lumps of soil which have been carried on farm implements on wet days, when the sandy soil is more likely to stick together. It is also likely to spread from diseased sprouts which have been grown in a seed bed, the soil of which has been taken from a previously infected field. Washing by rain is also likely to carry the disease in the field. In lands with a natural slope, pox will be seen to spread downward in the direction of the waterfall; that is, from the highest to the lowest point, but seldom in the opposite direction.

The Organism. That *Cystospora batata* is the cause of pox has been amply proved by Elliott (18) and by the author (100). The gross morphology of *Cystospora batata* has already been indicated by Elliott (19). The organism must undoubtedly hibernate in the soil as cysts. This stage probably enables it to resist drouth and cold. Careful experiments have shown that freezing will not affect *C. batata* in infected soil. Pox-sick soil in flowerpots, exposed to outdoor freezing weather during the entire winter will not show the least weakening in the virulency of the causal organism. Similarly, ordinary drying of the soil in the greenhouse for 12 months, will have no injurious effect on *C. batata* in the infected soil.

The cysts (Fig. 7, e and f) are heavy-walled, and each individual may contain large numbers of swarm spores or amoebae. When the latter are ready to emerge, the cyst wall becomes thinner, until finally the swarm spores break through. Infection of the host may take place by the penetration of individual amoebae into the epidermal host cells. This is especially the case with root tips. Ordinarily, however, infection is by means of a plasmodium or by both methods. The swarm spores are round, but slightly tapered at both ends, and possess a single, short flagellum. Occasionally the swarm spores fuse in pairs, but from the author's observations this does not seem the rule. They are usually active after emergence from the mother cyst. The period of activity, although varying from 1 to 7 days, is usually short, often less than 30 minutes. They gradually increase in size, taking on the amoeboid, then the plasmodial form. At this stage a large number of nuclei are formed by mitotic division. Nuclear division seems to proceed by a definite mathematical ratio of 1, 2, 4, 8, etc. Single plasmodia may often contain 200 to 300 nuclei. At this stage and before escaping, the plasmodium becomes more dense and thickly granular in the center, surrounded by a clearer zone which later becomes a thick cell of the cyst. The latter apparently undergoes a short period of rest, during which time the swarm spores are formed. These in turn emerge and undergo the same life cycle as above described. Thus, in a single infected root tip or in a pox spot, several crops of swarm spores may be formed within the host cells, each generation of which advances farther. Finally all the plasmodia seem to collect, cease advancing, turn outwards, and leave the pit for the soil. It is probable that the plasmodia in the soil encyst and pass the winter in that way.

In describing pox (soil rot) Halsted (27) has figured a new fungus of a new genus and species, which he named *Acrocystis batatas* E. and Hals. The latter was practically the only described species of the genus Acrocystis. However, Halsted's drawings of Acrocystis are really mistaken figures (Fig. 7, g) for *Cystospora batata,* a myxomycete, and not a fungus. It has been proved that pox of the sweet potato is caused by a myxomycete, *Cystospora batata* Elliott. It is therefore evident that *Acrocystis batatas* does not exist at all, and that the genus Acrocystis is not valid.

Other Crops Susceptible to Pox. As will be seen presently, pox attacks not only the sweet potato but other hosts as well. In the summer of 1914 an old Virginia grower stated to the author that he never plants white (Irish) potatoes (*Solanum tubersoum*) on the same land where sweet potatoes affected with pox have grown, for the white potato, too, is subject to the same disease. Upon further inquiry it was found that the same practice was observed by most growers there. Bearing this in mind, in 1915, Irish potatoes were planted side by side with sweet potatoes in a field badly infected with pox. Observations were made from time to time by pulling out growing plants. Unmistakable symptoms of the pox were noticed at a very early stage. At harvest, about 60 per cent of the tubers of the Irish potato were affected with pox. The pox spots on the Irish potato seemed to be more shallow. Potato growers in Virginia maintain that some varieties of Irish potatoes seem to be more resistant to pox than others. The Irish Cobbler is apparently least resistant. This statement is worthy of further investigation. That pox is a serious disease of the Irish potato there seems no doubt. It is found in abundance in Virginia and is often mistaken for common scab.

Elliott (19) too, has recorded the Irish potato as a host to pox. There seems no doubt that the disease on the Irish potato is far more widespread than has heretofore been recognized; it is very probable also that it has been mistaken and confused with other troubles. Morse and Shapovalov (71) and more recently Ramsey (83) in their work on the disease caused by Rhizoctonia sp., have noticed a pitting disease of the Irish potato that has been attributed to that fungus. No doubt Rhizoctonia sp. is abundant in these pits, but from the illustrations given by Morse and Shapovalov it is evident that they were dealing with the pox, and that the trouble caused by species of Rhizoctonia was merely secondary.

Elliott (19) and the writer (100) have already stated that the pox spots on the Irish potato are of a shallow type; however, under Maine conditions, it is very probable that Rhizoctonia sp. merely enters as a result of the injury caused by *Cystospora batata,* and that having once penetrated, it is capable of working in farther, thus deepening the pit. Prof. Ramsey was kind enough to send the writer slides of his so-called "Rhizoctomia pits." In every case these slides were sections of cracked "pits." A careful examination showed a few remaining cysts irregularly scattered in the tissue of the "pit" area. Furthermore, the largest quantity of filaments of Rhizoctonia sp. were found in the center, and at each side of the crack of the "pit" was a place from which the invading plasmodium migrated back to the soil. It seems very probable that the growth of Rhizoctonia sp. in the "pits" is limited by the secretion of a toxin which the plasmodium of *C. batata* leaves in the occupied cells before migrating.

Pox on the Irish potato has so far been found to attack the tubers only, and not the roots and rootlets, as it does with the sweet potato. Infection apparently takes place at a lenticel, as Ramsey also found.

The turnip (*Brassica rapa*) is also susceptible to pox. In the summers of 1916 and 1917 the author sowed turnip seed in soil infected with *Cystospora batata,* from which sweet potatoes had been badly diseased. A large percentage of the turnips showed unmistakable pox infection. Here, however, the spots were more superficial than on the Irish potato. It is now suspected that the beet (*Beta vulgaris*) and tomato (*Lycopersicon esculentum*) are also subject to the attack of this disease.

An Actinomyces Associated with Pox. Of the many bacteria and fungi isolated from pox, a species of Actinomyces is very often obtained from diseased spots. Inoculation experiments with pure cultures of this organism showed that it is capable of producing a spot which, although not resembling pox, may penetrate equally deep in the host tissue. This species of Actinomyces was isolated from sweet potato material in Delaware, as well as from specimens grown in Texas. Cultures of the organism were made on various media, and parallel with a strain of *Actinomyces chromogenus* from the Irish potato, secured through the kindness of Dr. W. J. Morse, of the Maine Experiment Station. The two organisms appeared to be distinct, and it was thought that the species of Actinomyces grown on the sweet potato was a new one, to which the name *Actinomyces poolensis* Taub. was given.

The sweet potato Actinomyces possesses strong proteolytic activities, which may perhaps serve as a clue to its pathogenicity. The cultural earmarks of this organism are as follows:

A very good growth is produced on different organic media and also on synthetic media containing glucose or glycerine. A good, but uncharacteristic growth was produced on Lubenau's egg medium, Petroff's medium, glycerine, beef-infusion agar, and Loeffler's blood serum. Growth restricted, cream-colored, aerial mycelium gray to musty-gray on Krainsky's Ca-Malate agar; thin cream-colored growth, surface becoming covered with an ash-gray aerial mycelium, on Czapek's solution agar, in which glucose or glycerine took the place of sucrose: the growth is heavy, yellowish, aerial mycelium abundant, gray or white. No soluble pigment is produced on any of the media studied. On potato plug the growth is light brown, no aerial mycelium is produced, plug is not colored. Milk at 37 degrees C. is hydrolized in 15 days. Gelatine at 15 degrees C. is slowly liquefied (10 mm. in 20 days), with no color production in the liquefied portion; the growth is light brown, with no aerial mycelium. On glucose broth a flocculent uncharacteristic growth is produced. The organism grows very readily on all the media at 37 degrees C.

Microscopically the following points are to be noted: Spirals are not produced; the aerial mycelium soon breaks up into short cylindrical spores, although many spherical spores are found.

Actinomyces poolensis is a superficial wound parasite, usually found following the pox spots produced by *Cystospora batata.* The former organism will not grow on healthy tubers of the Irish potato. Structurally *A. poolensis* and *A. chromogenus* differ very little. They can be distinguished only pathologically and when grown parallel on different media.

Methods of Controlling Pox. Halsted, in his extensive field work on the control of pox, found that a broadcast application of 300 or 400 pounds per acre of both sulphur and kainit would decrease the disease and also increase the yield of marketable potatoes. From a practical point of view it was necessary to ascertain whether an alkaline or an acid fertilizer would favor or control pox in the field. Accordingly an infested field that had been chosen received a normal application of 1,000 pounds per acre of a potash phosphate with the following guaranteed analysis: Ammonia 6 to 8 per cent, available acid phosphate 7 to 8 per cent, potash 5 per cent. The land was then divided into three plots. The middle remained as a check and received no further treatment. The plot to the right received an additional application of acid phosphate (guaranteed analysis, 14 per cent of available phosphoric acid) at the rate of 2,000 pounds per acre. The plot to the left received an additional application of hydrated lime (guaranteed analysis, 65 per cent of calcium oxid) at the rate of 2,000 pounds to the acre. The results obtained were very striking. The control plot gave an average of almost 60 per cent affected roots. The lime plot increased the amount of affected roots to about 85 per cent. The percentage of diseased roots in the acid phosphate plot was 32. This seemed to indicate that an acid fertilizer has a tendency to keep the pox in check, whereas lime has the opposite effect.

Considerable differences seem to exist in the resistance of varieties of sweet potatoes to the disease. Of the limited number tested in 1915 in Delaware, the following is a tentative classification of their resistance: (a) apparent total freedom from disease (Dahomey, Red Brazil, Pearson); (b) from 1 to 20 per cent infected

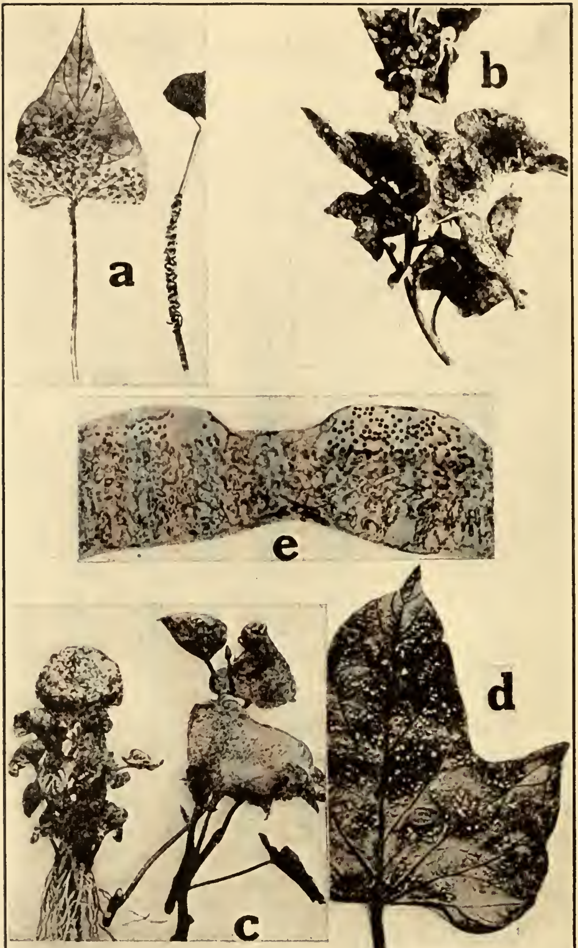

Fig. 8. Slime Mold.

a. Sweet potato leaf and petiole covered with slime mold *Physarum plumbeum*. *b* and *c*. Plants covered with slime mold, *Fuligo violacea*. *d*. White rust. *e*. Cross-section of leaf to show sorus of spores of *Cystopus ipomoeae panduranae*.

(Big Stem Jersey, White Yam, Yellow Strassberger); (c) from 20 to 90 per cent infected (Goldskin, Big Leaf, Upriver).

Steaming the soil for six hours at 20 pounds pressure will free it from the pox organism. This also seems to be true when the infected soil is treated with formaldehyde at the rate of 1 pint in 20 gallons of water, applied at the rate of 1 gallon of the solution to each square foot of soil space. However, since it is very doubtful if the disease is carried with the seed in the soil of the seed bed, soil sterilization would hardly seem warranted unless it aimed also at controlling black rot. Likewise it seems hardly necessary to treat the seed for that alone. It is not definitely known how long *Cystospora batata* would persist in the soil without a suitable host. Observations of practical growers differ greatly in this respect. Some assert that at least a 10-year rotation is necessary to free the land from pox; others, and these seem to be in the majority, maintain that a 3-year rotation is sufficient. Soil conditions, it seems, are an important factor. Pox is more severe in the lightest of the sandy soils, and less so in the heavy clay loams.

Powdery Slime Mold

Caused by *Fuligo violacea* Pers.

Frequently, the plants in sweet potato hot-beds are covered with a thick slimy growth (Fig. 8, b and c), which is at first soft and a dirty white, gradually becoming yellowish, and when mature purple. This growth readily breaks up at the least touch and liberates a copious, purplish powder which consists of the spores of the organisms. The slimy growth appears in patches of various sizes, ranging from a quarter of an inch to three feet in dimensions. The causal organism, *Fuligo violacea* Pers., is not a parasite as it lives only superficially on all the exterior parts of the plant. However, when the leaf stomata are covered so as to shut out the light, the general effect is that of suffocation, since plants thus affected become yellow and languid and look messed up.

Another slime mold organism, *Physarum plumbeum* Fries., also occurs on sweet potato plants in hot-beds. However, it forms no lumpy growth, but appears as delicate, star-shaped, cup-like incrustations (Fig. 8, a). *Physarum plumbeum* is not a parasite; it lives only superficially on the petioles and foliage, and exerts the same indirect harmful effect as *Fuligo violacea.*

To prevent the rapid spread of the above slime molds, infected patches should be carefully removed and destroyed by fire. This should be done before the causal organisms ripen into the spore-bearing stage. Overwatering and insufficient ventilation will favor the growth of these slime molds, which are seldom met with in the fields.

White Rust

Caused by *Cystopus ipomoeae-panduranae* Farl.

Distribution and Economic Importance. White rust is probably found wherever sweet potatoes are grown. It has been observed by the author in New Jersey, Delaware, Maryland, Virginia, Alabama, Georgia, Mississippi and Texas. Harter (40) has also seen it in Iowa and says that it is widely distributed there.

White rust is a field disease which attacks foliage and petioles only; and is rarely found on the stem. It is of little economic importance, although it probably causes indirect losses in yields. While it is true that the sweet potato is grown only for its roots, nevertheless, a good crop depends on healthy and abundant foliage. The sugar and the starch in the sweet potato are not manufactured from the soil, but are made by the leaves from the air and then stored in the roots. The effect of white rust in killing much of the foliage is to curtail the amount of manufactured sugar and starch and this in turn, no doubt, results in a shorter crop.

Symptoms of the Disease. White rust appears when the plants have usually made good vine growth and when the hills are beginning to set, i.e., to form new sweet potatoes in the soil. A typical symptom of white rust then is the yellowing of the leaves in the center of the plant, which later turn brown, shrivel, and die.

In carefully examining the center leaves as they begin to yellow, we see that on the under side of such leaves there are many minute, white raised pimples (Fig. 8, d and e), each of which, when it is touched with the finger, sheds a white dust, made up of millions of spores of the fungus. Each white pimple on the under side of the leaf is denoted by a small yellow area on the upper surface. In cases of mild infection there are usually few pimples on a leaf, but when the disease is severe, the leaf is literally peppered with them. White rust is worse when the weather is dry and the nights are cool, and it is more abundant in the shaded portions of the field.

The Organism. The first mention of the white rust organism in the United States was made by Halsted (27), who spoke of it as *Cystopus ipomoeae-panduranae*

Farl. In Saccardo Sylloge Fungorum 9:341, an organism *Cystopus ipomeae-panduranae* (Schw.) Stev. et Sw. is described as found on *Ipomoeae hederaceae, lacunosae, leptoplyllae et panduranae.* In 1904, Stevens (88) adapted the generic name Albugo, and referred to the sweet potato organism as *Albugo ipomoeae-panduranae* (Schw.) Sw., which is also adopted by Harter (40) and others. In 1909 Duggar (17) refers to *Cystopus convulvulacearum* Otth., which is also mentioned in Saccardo Sylloge Fungorum 9:340, found on species of *Ipomoeae gossypioidis.* In this connection, Duggar (17) states that *Cystopus convulvulacearum* is also found on the sweet potato. Harshberger (52) speaks of the white rust organism as *Cystopus ipomoeae panduranae* Farl.

It is thus seen that there seems to be considerable confusion and lack of agreement as to the proper name. It might be asked if *Cystopus ipomoeae-panduranae* Farl. is the same as *Cystopus ipomeae panduranae* (Schw.) Stev. et Sw. It might be further asked if *Cystopus convulvulacearum* Otth. is the same or similar to the above two mentioned.

Host Relationship. Halsted (27) stated that *Cystopus ipomoeae-panduranae,* the cause of the white rust of the sweet potato, also attacks many other hosts of the morning glory family, especially the wild morning glory. The disease on this latter host causes large swellings and galls, in which are formed the oospores. Stevens (91) states that *Albugo* (*Cystopus*) *ipomoeae-panduranae* (Schw.) Stev. et Sw. attacks not only the sweet potato but also various species of Convulvulaceae, such as the morning glory and the moon flower.

In 1915, McClintock (64) was unable to infect sweet potato plants with spores from the wild morning glory white rust, and morning glory plants with spores from the sweet potato white rust. Spores of white rust from each of these hosts, however, infected healthy plants of its respective hosts. Similar tests were made by the author in 1916 and 1917, and the spores of the white rust from the sweet potato and the wild morning glory were subjected to freezing as was recommended by Melhus (68), but with no effect. This seems to indicate that the causal organism of the white rust of sweet potatoes is probably a distinct species from that of the wild morning glory. The symptoms on the latter are always accompanied by swellings or large galls on the blossoms, foliage, petioles, and stems. Such symptoms have never been observed by the author to occur on the sweet potato.

Control. With our present meagre knowledge of white rust, it is not possible to formulate definite methods of control. Crop rotation seems to be no factor of importance. The disease is found on new land as well as on land where sweet potatoes were grown several years in succession. Of the thirty varieties grown by McClintock (64) none has shown to be entirely immune. On the other hand, some varieties seemed to be slightly more resistant than others. From the author's observations, it seems that the Southern Queen variety possesses considerable immunity to the white rust. High temperatures, frequent rains, heavy dews, and a high relative humidity in the air favor the spread of this disease.

CHAPTER IX

SPECIFIC DISEASES

Soft Rot

Caused by *Rhizopus nigricans* Ehr.

A Field Trouble. Soft rot is not primarily a field disease; however, it is frequently met with at digging, causing considerable damage. McClintock (64) reported a serious outbreak in Virginia of soft rot in the field. For the harvesting of the sweet potatoes in that state, a vine cutter made from a disc harrow with all but two discs removed is generally used. In cutting the vines, the discs penetrate deeply in the soil, and badly cut and bruise many of the potatoes, which, as a result, soft-rot just as they are dug. Uninjured roots in the same hill remain free from the disease. From this it seems evident that the cutting of the vines should be done at the time when the potatoes are dug. It is unsafe to leave injured potatoes (this also applies to potatoes struck by frost) in the ground for more than twelve hours. Furthermore, no vine cutter should be used that goes in the soil deep enough to injure the roots.

As a field disease, soft rot may be expected in heavy soils with poor drainage, and during prolonged wet weather before or during harvesting. The disease is especially aggravated, when, during harvesting, a plow is used that bruises or injures the potatoes.

As a Seed Bed Trouble. Soft rot is a disease which is often met with in the hot-bed. Here the potatoes may rot as soon as they are bedded, or later at various intervals. Soft rot in the hot-bed is favored by bedding bruised potatoes and by failure to disinfect them with corrosive sublimate (see p. 24). Sudden rising or lowering of temperature, over-watering, poor ventilation, walking upon and trampling the roots during bedding or when drawing sprouts are all conducive to soft rot in the hot-bed. Care exercised in these directions will reduce to a minimum the losses from soft rot.

As a Storage Trouble. The seriousness of soft rot in storage was pointed out by Halsted (27), and, in fact, by all writers and investigators of sweet potato diseases. In Delaware, the author (103) estimated about 30 per cent loss in storage. Wilcox (114) and Carver (8) state that soft rot is one of the worst storage diseases. The conditions which favor this rot indoors are the following:

1. Rough handling, bruising the potatoes in the field while harvesting, hauling and filling the storage house.
2. Storage of potatoes frosted in the field.
3. Frosted potatoes due to a loose house, sudden drop of temperature or lack of fire in the house during cold weather.
3. Poorly ventilated house.
4. Overcrowded house.
5. Overheating and lack of ventilation.
6. Frequent handling of sweet potatoes during storage.

Symptoms. Soft-rotted potatoes are at first soft and mushy. When pressed with the finger, the tissue will readily yield and break open, and a clear brownish liquid will spill out. The rot usually starts from either end of the potato. When there is no crack on the root, it will merely soft-rot, gradually shrink (Fig. 9, a), because of the evaporation of its interior moisture, and finally dry and become mummified. When the potatoes are taken out for shipment, the dried mummies show no evidence of previous relationship to the early soft rot stage and therefore many growers do not recognize soft rot as a serious storage disease. When freshly soft-rotted potatoes are cut or bruised, the causal fungus, *Rhizopus nigricans,* will send out its fruiting stalks and resemble a whiskered growth (Fig. 9, b). When such potatoes are placed in a wire basket and under a closed bell jar, the Rhizopus growth with its fruiting stalls will overrun the potatoes and the basket (Fig. 9, d), and form a thick matted fungus growth. In the bins, the presence of soft rot may always be detected by a liquid dripping from the rotted potatoes and wetting the healthy ones nearby. The wetting frequently favors infection of the neighboring healthy roots, although this does not always occur.

Odor of Soft Rot. Very often we hear storage men accuse the soft rot of emitting strong disagreeable odors. Similar statements are also found in the literature. Price (80) found that when potatoes are attacked they become soft and worthless and give off an offensive odor. Starnes (87) too, observed that the entire contents of a bin may be reduced to a pulpy mass of corruption, emitting a most disgusting odor. Contrary to general belief, soft rot in the bins is at first odorless for a week or ten days. After that time acetic fermentation sets in, and this becomes quite noticeable. It seems that this odor attracts the females of a species of fruit fly which lay their eggs in the rotting potato. At this

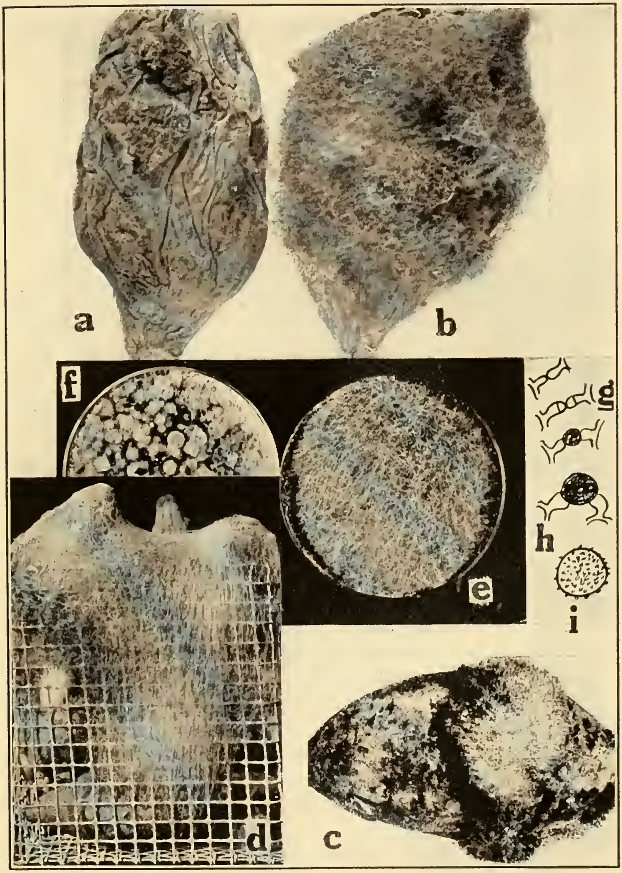

Fig. 9. Soft Rot.

a. Sweet potato freshly soft-rotted. *b* to *d*. Soft-rotted sweet potatoes covered with the fruiting stalks of *Rhizopus nigricans* (after Harter, L. L.). *e*. Pure culture of *Rhizopus nigricans* from tissue of a freshly soft-rotted sweet potato. *f*. Pure culture of *Oospora lactis* from tissue from a soft-rotted sweet potato 20 days old. *g*. and *h*. Stages in zygospore formation of *R. niger*. *i*. Mature zygospore.

stage badly affected storage houses are literally swarming with these gnats. The acetic fermentation may last for a week or ten days. After that time, the affected potatoes have partially dried out and fungi, such as *Diaporthe batatatis* (Hals.) Hart., *Fusarium batatatis* Woll., *Sclerotium bataticola* Taub., and many others may gain entrance. It sometimes happens that putrefaction follows the acetic fermentation. Bacteria are no doubt involved in this process, for at this time the affected potato is fairly putrid and the odor is erroneously attributed to soft rot.

The Organism. The general morphology of Rhizopus is well known. The spore germinates easily by sending out a germ tube which grows and branches rapidly, forming a mat of mycelial growth, also sending out many stolons. On these stolons are borne the sporangiophores (Fig. 10, c to e). The latter usually develop at the base of origin a few rhizoids which according to Swingle (94) help to nourish and anchor the organism. Each sporangiophore bears a single spherical sporangium. The protoplasm in young mycelium is seen to be slowly streaming (Fig. 10, g). The cytoplasm in young sporangia is densest next to the wall and clearest in the center. The formation of spores begins when the columella is well apparent. The spores are at first angular and covered by a thin plasma-membrane. When fully ripe, they round off and take on a firm wall. The spores are set free by the bursting of the sporangium wall without its being thrown off. The mature spores are ovoid in shape and vary in size. The spore walls are marked with longitudinal ridges (Fig. 10, f).

The development of sexual-resting or winter spores (zygospores) has been worked out by Blakslee (4). Hyphae of two distinct mycelia, designated as + and —

strains, are formed, each giving rise to lateral club-shaped branches. The tips of these branches (gametes) come together, and each is cut off from its original branch by a transverse wall. The contents of two gamete cells fuse, and the result is the resting sexual spores or zygospore (Fig. 9, g to i). The latter has a thick, warty, brown coat. The zygosporic stage seems to play no important rôle in the life cycle of *Rhizopus nigricans,* as the fungus is carried over from year to year through its sporangiospores (Fig. 10, f).

Other Hosts of Rhizopus Nigricans. Besides on the sweet potato, *R. nigricans* is more frequently found growing on decayed vegetables, and especially on moist bread, whence the name bread mold. According to Halsted *R. nigricans* also produces a soft rot on quince fruit.

In 1909, Orton (75) called attention to a decay of the white or Irish potato which is generally known as "leak" or "melters," and which he attributed to *Rhizopus nigricans* Ehr. In 1909, Morse* mentioned a fruit rot caused by a species of Rhizopus. Haslam† found the fungus *Rhizopus nigricans* in great abundance on corn, apparently causing blind staggers in horses. Edgerton‡ described a soft rot of the fig which he attributed to the same fungus. He claimed in some cases a loss of more than 90 per cent of the fruits. Stevens and Wilcox (92) have proven that *R. nigricans* causes a rot of strawberries in transit. In Texas it causes a soft rot of squashes in the field as well as in storage.

* Morse, W. J., *Notes on plant diseases.* Maine Agr. Expt. Sta. Bul. 164 : 1–28, 1909.

† Haslam, T. P., *Meningo Encephalitis* (blind staggers). Kansas Agr. Expt. Sta. Bul. 173 : 235–251, 1910.

‡ Edgerton, C. W., *Diseases of the fig tree and fruit,* Louisiana Agr. Expt. Sta. Bul. 126 : 5–20, 1911.

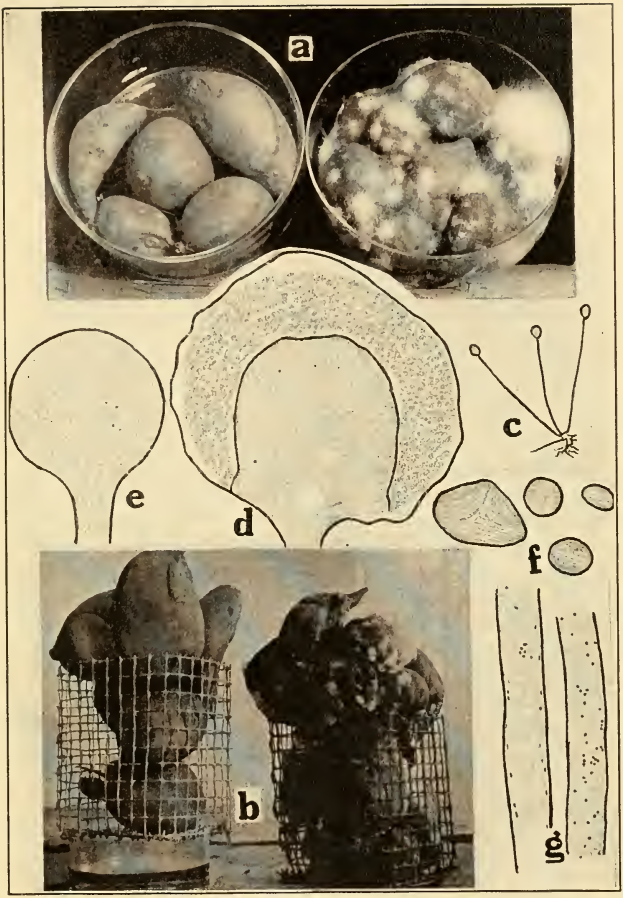

Fig. 10. Soft Rot.

a. Artificially inoculated sweet potatoes with spores of *Rhizopus nigricans;* to the left, chamber kept open and dry, healthy; to the right, chamber kept covered and moist, soft-rotted. *b*. Same as *a;* to the left, kept under bell jar on receptacle which contained sulphuric acid, the latter absorbing the moisture in the bell jar, healthy; to the right, no sulphuric acid, soft-rotted. *c*. Group of sporangiophores bearing sporangia of *R. nigricans*. *d*. Sporangium of *R. nigricans* in which the spores are completely formed. *e*. Young sporangium of *R. nigricans*. *f*. Ripe spores of *R. nigricans*. *g*. Longitudinal section through stolon to show distribution of cytoplasm in *R. nigricans* (*c* to *g* after Swingle, D. B.).

Life History of Rhizopus Nigricans. Experiments by the author have shown that *R. nigricans* is not carried over from year to year as mycelium in the soft-rotted potatoes. On the contrary, after the disease runs its course, the fungus within the tissue begins to die out gradually. Cultures were made of the fungus from soft-rotted potatoes of various ages. Each day when the platings were made (Fig. 9, e), two infected roots were used at a time. Nearly the entire content was cultured, making a total of thirty to fifty poured plates each day. From the ninth to the twelfth day, the Rhizopus fungus was seen to lose rapidly in vigor. At this stage, the platings yielded a very weak growth of Rhizopus followed by species of *Oospora lactis* (Fres.) Sacc. and *Oosporoidea lactis* (Fres.) Sums (Fig. 9, f), respectively. By the twelfth to the fifteenth day, the fungus *R. nigricans* had disappeared completely and, instead, pure cultures of *Oospora lactis* and *Oosporoidea lactis,* as well as putrefying bacteria, took its place. By the fifteenth to the twenty-fifth day the above two fungi had gradually disappeared, giving place to more colonies of bacteria, several species of Fusaria, *Trichoderma Koningi* Oud., *Nectria ipomoeae* Hals. and several others. Microscopic examination of crush mounts, on the respective dates when the platings were made, revealed some very interesting facts. During the first week, when the infected roots yielded pure cultures of *R. nigricans,* the hyphae under the microscope were hyaline and the protoplasmic granules very even. As the fungus gradually began dying, the mycelium as well as the protoplasmic granules turned brown. Many filaments too were found empty and shriveled, altogether indicating actual death of the fungus. It was further observed in studying the crush mounts, that the fungus in the host tissue is both inter- and intra-cellular. The middle lamella of the cells are in most cases dissolved and the starch grains corroded. This is no doubt the result of enzyme action. Harter and Weimer (41, 47 and 110) have found that *Rhizopus tritici* Saito is capable of destroying the sweet potato through powerful enzymic action.

Susceptibility of Sweet Potatoes to Rhizopus. Work done by Harter and Weimer (49) showed the following: 1. Very susceptible varieties include, Gold Skin, Little Stem Jersey, Georgia, Early Carolina, Red Brazil, Haiti, Yellow Belmont and Dooley. 2. Very resistant varieties of which may be mentioned Southern Queen and Nancy Hall. 3. Intermediate varieties such as Porto Rico, Big Stem Jersey, Triumph, Pierson, Florida and Dahomey.

Storage Conditions Which Favor Soft Rot. Since soft rot is a very serious storage disease, it is necessary to determine what if any indoor conditions particularly favor its spread. Extended studies and observations by the author in over three hundred sweet potato storage houses have indicated that stagnant moisture and poor ventilation are both unfavorable to sweet potatoes. A minimum of soft rot is found in storage houses which are provided with ample means of ventilation. Less soft rot is also found in those houses, where the relative humidity of the indoor air seldom rises above 70 per cent. Through properly constructed houses this condition is attained.

In order to determine the effect of moisture on soft rot, the following simple experiments were carried out:

Moisture Experiment with Crude Sulphuric Acid. Bell jars were used to cover wire baskets (Fig. 10, b) $5 \times 5 \times 5$ inches containing sound sweet potatoes. These were kept in the laboratory one week to determine the presence or absence of soft rot infection. Crude sulphuric acid was used as a drying agent, being placed in flat glass dishes 5 inches in diameter and 2 inches deep. The amount of acid used is indicated in Table 23. Two of the baskets were left as checks without the drying agent; the remaining six were subjected to the acid. Duplicates marked *A* and *B* in Table 23 were run in each experiment. Before being covered with the bell jars, each root in the baskets was smeared with spores from pure cultures of *R. nigricans,* applied with a camel's-hair brush. The results obtained are given in Table 23.

From Table 23 it is seen that both checks were infected with soft rot the third day of the experiment, giving an average of 85 per cent infection. Where 100 cc. of sulphuric acid was used, infection was retarded from twenty-three to thirty-eight days, and the amount of infection was only 7 per cent. As the acid was reduced from 100 to 50 cc., infection was retarded fifteen or sixteen days, and increased to about 80 per cent. As the acid was further decreased to 25 cc., infection was retarded ten or eleven days, but increased from 80 to 90 per cent, nearly equalling the per cent of infection in the checks. It is evident, therefore, that the more acid we use, the greater its power of absorbing the moisture which is given off and, therefore, the greater the time required for infection.

Ring Rot

Caused by *Rhizopus nigricans* Ehr.

Ring rot was described by Halsted, who attributed its cause to the fungus, *Nectria ipomoeae* Hals. However, the author (97) has definitely proved that the

TABLE 23

Effect of Drying with Sulphuric Acid on Soft Rot

Kind of Treatment	Checks		100 cc. Acid	
	A	B	A	B
Weight in grams of sweet potatoes at first date of experiment	1363	1363	1465	1347
Weight in grams of same at end of experiment	1243	1195	1077	1056
Date of inoculation	Dec. 5, 1912	Dec. 5, 1912	Dec. 5, 1912	Dec. 5, 1912
First date of infection	Dec. 8, 1912	Dec. 8, 1912	Jan. 12, 1913	Dec. 28, 1912
Per cent. of infection	90	80.85	7	7.7
Amount of water given off in grams	120	167	388	291

Kind of Treatment	50 cc. Acid		25 cc. Acid	
	A	B	A	B
Weight in grams of sweet potatoes at first date of experiment	1363	1290	1360	1307
Weight in grams of same at end of experiment	1135	1040	1132	1090
Date of inoculation	Dec. 5, 1912	Dec. 5, 1912	Dec. 5, 1912	Dec. 5, 1912
First date of infection	Dec. 20, 1912	Dec. 21, 1912	Dec. 15, 1912	Dec. 16, 1912
Per cent. of infection	83	80	80	90
Amount of water given off in grams	228	250	228	217

disease is induced by *Rhizopus nigricans,* the cause of soft rot. Like soft rot, ring rot is primarily a storage

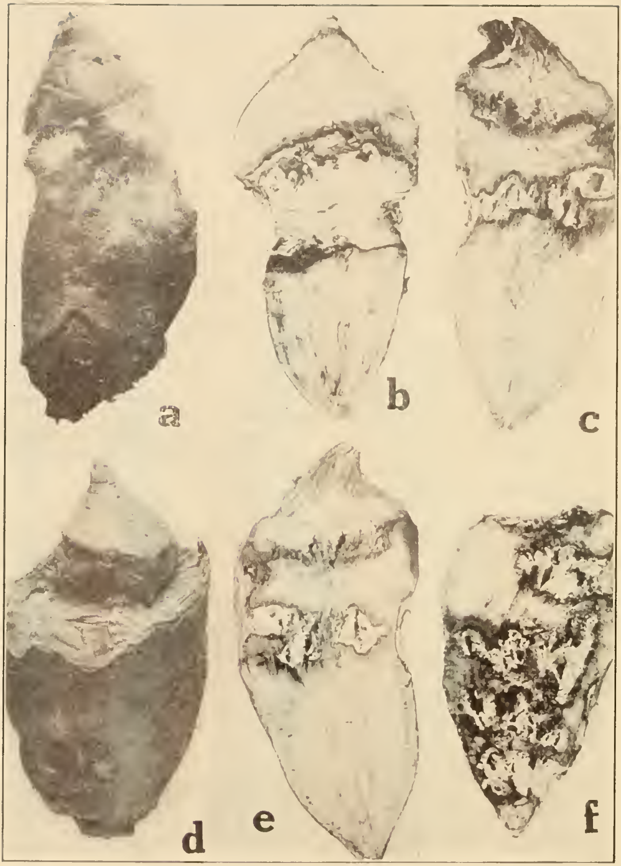

Fig. 11. Ring Rot.

a. Freshly ring-rotted sweet potato placed in a moist chamber overnight. Note the Rhizopus growth on the ringed area. *b.* to *f.* Various forms of ring rot.

disease, although it occurs in the field and in the hotbed.

Symptoms. Before describing the symptoms, it must be stated at the outset that there are two forms of ring rot, both of which are stages of the same disease. The first stage is the soft ring. This is characterized by a soft-rotted area which girdles the root, thereby forming a complete ring. This ring may be formed in the center, at the tip end, or at any part of the root. The formation of the soft ring, like soft rot, takes place as soon as the sweet potatoes are put in storage. As the roots are usually stored in bulk in bins, and as the soft ring, like the soft rot, is confined to roots more or less deeply buried in the bin, the disease is overlooked. The soft ring, like the soft rot, is at first odorless, but in a week to ten days it is followed by a characteristic fermentation. Fruit flies which are constantly associated with soft rot in storage are also associated with the soft ring. The soft ring gradually begins to dry by losing the water which resulted from the breaking down of the starch. The drying is noticed by shrinkage and contraction of the entire ringed area, forming a slight groove (Fig. 11, b to f). In two to six weeks the ring becomes very dry and more or less hardened, varying with the nature of the fungi, which act as secondary invaders. This then brings us to the second form or dry ring rot, which is nothing more than the last stage of the soft ring in which the primary parasite has died out (Fig. 11, b).

Proofs that Ring Rot and Soft Rot Are Both Caused by the Fungus R. Nigricans Ehr. Ring rot is similar to soft rot except that in the former the decayed area is limited to a ring.

1. Ring rot, like soft rot, starts when the sweet potatoes are first brought into storage.

2. In fresh ring rot, as in fresh soft rot, the fungus does all the damage in a very short time, usually within twenty-four to forty-eight hours. The infected parts in both rots are very soft and water-soaked. In both, the water may leak out through some break in the epidermis, the tissue drying in proportion as the water is lost.

3. Like soft rot, ring rot, under storage conditions, does not send out sporophores unless a break occurs on the epidermis and this usually happens through the weight and pressure of the surrounding roots. In this case the sporophores are short, very numerous, closely packed, and borne at the break in the epidermis (Figs. 9, c; 11, a).

4. As in soft rot, when roots freshly infected with ring rot are placed in a moist chamber, the fungus *R. nigricans* grows out at the area of the ring within twenty-four hours (Fig. 11, a).

5. In plating out tissue from sweet potatoes freshly infected with ring rot, one obtains a pure culture of the Rhizopus fungus within twelve to sixteen hours.

6. Within a week to ten days after infection, the diseased tissue of ring rot, just as in soft rot, is odorless, but is soon followed by fermentation. At this stage the causative organism begins to die.

7. Ring-rotted sweet potatoes, like soft-rotted ones, after reaching an age of ten days to three weeks, upon being placed in a moist chamber, fail to develop any Rhizopus growth from the infected area. Platings made from these roots fail to produce any Rhizopus growth, but on the contrary produce fungi like *Oospora lactis, Oosporoideae lactis* and bacteria (Fig. 9, f). Crushed mounts of the tissue from old ringed areas under the microscope reveal the presence of the Rhizopus fungus, the filaments, however, being empty or the

protoplasm browned and broken up into small granules, indicating the absence of life in these hypae.

Control of Soft and Ring Rot. The factors which are favorable for the development of these diseases in the field, the hot-bed and in storage have already been pointed out. Much can be done to reduce the losses to a minimum. This is especially true under storage conditions. What is primarily essential is an abundance of ventilation wherever the weather is favorable. This is accomplished only in properly built houses. (For further discussion see p. 216.) In the seed bed soft rot and ring rot are controlled by dipping the seed in corrosive sublimate solution, see p. 24.

Other Parasitic Rhizopus. The work of Harter (50) has shown that there are species of Rhizopus other than *R. nigricans* which may produce decay on the sweet potato. These are as follows: *Rhizopus tritici, R. nodosus, R. maydis, R. reflexus, R. artocarpi, R. delemar, R. arrhizus,* and *R. oryzae. Rhizopus chinensis* and *R. microsporus* do not seem to be parasitic on the sweet potato.

Mucor Rot

Caused by *Mucor racemosus* Fes.

Symptoms. Mucor rot is strictly a storage disease, but of less economic importance than soft rot. The tissue of infected potatoes becomes clayish-white in spots, somewhat wet but spongy to firm (Fig. 19, f). When a rotted potato is broken open it pulls out in a fibrous, stringy manner, and has a distinct starchy odor. Mucor rot was worked out by Harter and his associates (51), who found it to occur only under low temperature conditions in storage. A temperature of 40 degrees F. and less is especially favorable for infection.

CHAPTER X

SPECIFIC DISEASES (*Continued*)

GIBERELLA ROT

Caused by *Giberella saubinettii* (D. and M.) Sacc.

GIBERELLA rot, like Mucor rot, is of little economic importance. It is only found on sweet potatoes in storage which were kept at a low temperature of about 40 degrees F. Under these conditions, Harter and his associates (51) were able to obtain infection. Diseased sweet potatoes are at first spongy in texture and brown in color. As the moisture escapes, the tissue becomes firm, hard, and mummified. The brown color is later replaced by a pinkish-brown tint.

DRY ROT

Caused by *Diaporthe batatatis* (E. and H.) Hart. and Field

Dry rot was first mentioned by Halsted (27) as occurring in New Jersey, the cause of which he attributed to an undescribed species of Phoma. Twenty-two years later, Harter and Field (43) recognized its importance, and succeeded after careful investigations in proving that dry rot was caused by the fungus, *Diaporthe Batatatis*. The disease is prevalent in New Jersey, Delaware, Virginia, Mississippi, Texas, Alabama, Indiana

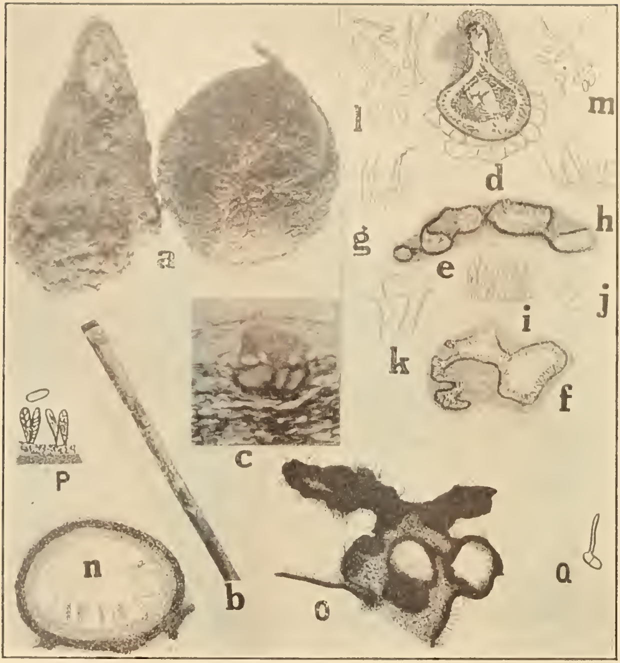

Fig. 12. Dry Rot.

a. Surface view of dry-rotted, mummified sweet potatoes. *b*. Sweet potato stem to show the pycnidia of the dry-rot organism. *c*. Photomicograph of cross-section through a pycnidium of the dry-rot organism. *d*. Same as *c* but longitudinal section. *e*. The same as *c* but tangential section showing the arrangement of the pycnidia in the stroma. *g*, *h*, and *k*. Stylospores. *f*. Tangential sections of sweet potato showing the chambering of a pycnidium which contains stylospores. *i*. Conidiophores and pycnidia. *j*. Club shaped stylospores found in connection with an ascospore strain. *l*. and *m*. Germination of pycniospores. *n*. Tangential section through a perithecium showing asci and ascospores. *o*. Perithecia borne in stroma. *p*. Asci and ascospores. *q*. Germination of ascospores. (*b*, *d* and *o* after Harter and Field.)

and North Carolina. It is probable that dry rot is of much wider occurrence. However, it may be easily overlooked as it is often obscured by stem rot and black rot.

A Field Trouble. It is not always easy to detect the disease in the field. The causal fungus works very slowly, and the pycnidia are formed only when the plant is in a dying condition. However, languid plants may be suspected of being affected with the dry rot. The fungus may attack any part of the vines, causing it to turn brown, shrunken, and in time become covered with the characteristic pycnidia (Fig. 12, a and b).

A Seed Bed Disease. The sprouts from diseased sweet potatoes seem at first healthy. Later, however, the vines start to die at the nodes and the disease frequently works down to the base of the sprout. The disease is found on old abandoned hot-beds, late in the season. It is very likely that dry rot is carried with the seed sweet potatoes, which communicate it later to the sprouts. Pycnidia of the causal organism form in abundance as soon as the vines die. They do not seem to develop on languid or partly living tissue.

A Storage Disease. In storage, the dry rot makes its appearance about six to eight weeks after digging. Diseased potatoes are dried and shriveled, later becoming hard, mummified, and covered with numerous pycnidia (Fig. 12, a).

The Organism. Diaporthe batatatis has two spore stages, the pycnidia and the asci. On the roots, the pycnidia are at first buried (Fig. 12, c) later breaking through the epidermis by a single opening (ostiole). The pycnidia are irregularly chambered (Fig. 12, d, e, f, o), and vary in size, often uniting and forming a continuous chamber. Frequently the opening (ostiole) is as long as the pycnidium itself (Fig. 12, d), which is carbonaceous at the outside wall, but hyaline in its inner part. The pycniospores are oblong to fusoid, hyaline, usually with two or three oil droplets, borne on long hyaline basidia (Fig. 12, h to m). In the pycnidia is also found another type of spore known as stylospores. These are filiform, curved, and hook-shaped bodies, which, as far as is known, no one has as yet succeeded in germinating (Fig. 12, k).

The ascogenous or winter stage was not found on dead sweet potatoes or sweet potato material. Harter and Field (43) found it on artificial media. The perithecia are formed in a stroma (Fig. 12, n), which is ashy gray within, black outside, and possesses subcylindrical beaks. The atroma contains from 9 to 25 perithecia, and the latter are subglobose (Fig. 12, o). The asci are clavate to cylindrical, and 8-spored (Fig. 12, p). The spores are arranged in one or two rows in the ascus, and are capable of germinating in three to five hours.

Control. The most favorable condition for dry rot in storage is a relative humidity of 80 per cent, accompanied by high temperatures. As far as possible the relative humidity should be maintained at about 65 to 70 per cent. This may be accomplished by carefully regulating the temperature and the ventilation.

In the hot-bed, infected potatoes should never be bedded, but should be boiled and fed to stock. The sound potatoes, before planting, should be disinfected with corrosive sublimate solution (see p. 24). The soil of the hot-bed should be changed every year. By carefully selecting healthy seed sweet potatoes, one may keep dry rot out of the field.

Phyllosticta Leaf Spot

Caused by *Phyllosticta bataticola.* E. and M.

Symptoms. The disease appears as roundish or angular spots which are more prominent on the upper side of the foliage (Fig 13, a). The spots are separated from the healthy tissue by a dark border. Inside this black line is a strip of brown tissue followed by a circular light area in the center. The pycnidia of the causal organism are situated in the center of the spots; they are slightly raised and domelike. The disease is found only on the foliage, and is not known to attack any other host.

Leaf spot occurs everywhere in the Southern States. It is less common in New Jersey, Delaware, Maryland, Iowa, Kansas and Illinois.

Control. The disease is practically of no economic importance, as it attacks the foliage at the end of the growing season. Plowing the old vines under deep is recommended.

Foot Rot (Die off)

Caused by *Plenodomus destruens* Hart.

Economic Importance. Foot rot is an old disease, but recently has been worked out by Harter (34), who first found it in Virginia. There, the damage from this disease runs as high as 50 per cent of the total crop. Foot rot has also been found in Ohio, Iowa, Missouri, Kansas, New Jersey, Maryland, and California.

Symptoms. Foot rot is primarily a hot-bed and a field disease. It is usually manifested as small brown to black spots on the stem of the plant near the soil line. The disease at first progresses very slowly, but eventually girdles the foot of the vines to about 4 to 5 inches. At this stage wilting begins, and numerous pycnidia form on the dead tissue. Foot rot becomes very conspicuous in about midsummer or later. In the majority of instances, diseased hills produce few or no marketable potatoes.

From the infected stem, the disease works downward to the roots, causing a brown firm rot (Fig. 13, b to c). During digging at harvesting, cuts or bruises will open the way to infection, and the disease will thus be carried from the field to the storage house.

The Organism. The pycnidia (Fig. 13, b) according to Harter (34) are at first buried, but later break through the epidermis, appearing as scattered black dots (Fig. 13, b). They are irregular in form and vary much in size. The pycniospores (Fig. 13, k) are borne on short basidia, and are oblong, rounded at both ends, hyaline, one-celled, and slightly curved. Together with the spores in the pycnidia are found hyaline, curved or straight bodies (Fig. 13, m), the exact function of which is as yet unknown.

Control. The causal organism is carried over winter on the dead vines in the field, and on the infected seed sweet potatoes. It is doubtful if it is carried over much in the soil. Dead vines from infected hills should be burned as soon as they have dried. In planting, the seed should be carefully selected, and diseased ones discarded. Before planting, the roots should be disinfected with corrosive sublimate (see p. 24). The diseased potatoes should never be dumped on the manure pile, and should not be fed raw to stock. The sand in the hot-bed should be changed every year. It is not as yet definitely known

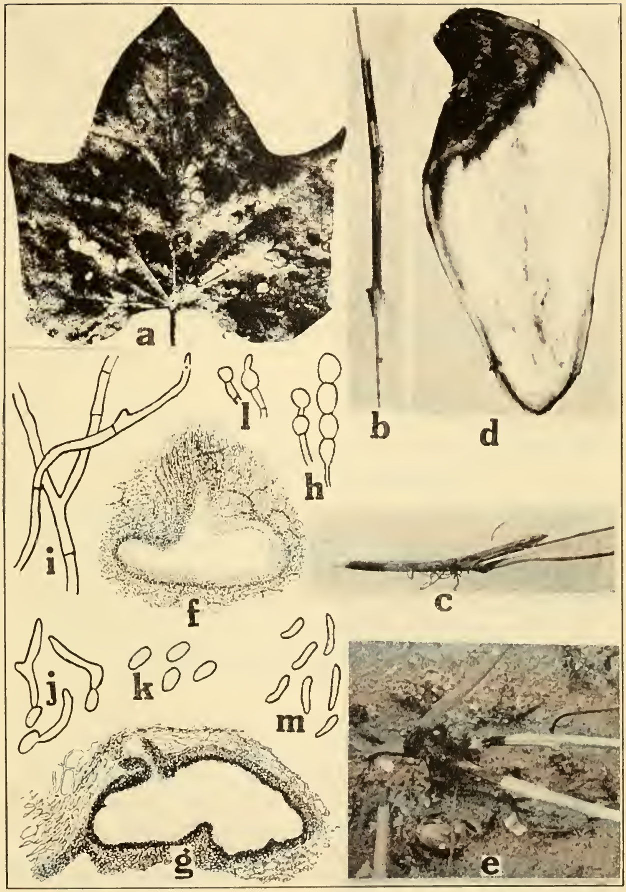

Fig. 13. Foot Rot.

a. Phyllosticta leaf spot. *b.* and *c.* Foot rot lesions on foot end of sweet potato vines. *d.* Longitudinal section showing foot rot extended from vines to root. *e.* Sweet potato hill, the foot end of vines being girdled by foot rot. *f.* Section of pycnidium on the root. *g.* Section through a pycnidium on the stem. *h.* and *i.* Chlamydospore-like buds found on the host and in culture media. *i.* Hyphae from pure culture. *k.* Pycniospores. *i.* and *j.* Germinating pycniospores. *m.* Club-shaped buds frequently found in pycnidia. (*e* after McClintock, all others after Harter.)

how long the disease will live over in the soil, but crop rotation should be practiced anyhow. According to Harter and his associates (51), the following varieties were inoculated with the foot rot fungus and positive infection obtained: Yellow Jersey, Big Stem Jersey, Red Bermuda, Extra Red Carolina, Southern Queen, Yellow Yam, Pumpkin Yam, Vineless Yam, Dooley, Triumph, Vineless Pumpkin Yam, Nancy Hall, Florida, General Grant, Vineless Yam, White Yam, Red Brazilian, and Dahomey.

Black Rot *

Caused by *Ceratostomella fimbriata* (E. and H.) Elliot
Syn. *Sphaeronema fimbriatum*

Economic Importance. Black rot is an important disease of the sweet potato. It occurs in the hot-bed, in the field, and in storage. It is probably found wherever sweet potatoes are grown. Black rot was reported in New Jersey, Delaware, Maryland, Virginia, Ohio, Illinois, Missouri, Iowa, Kansas, Oklahoma, Texas, Arkansas, North and South Carolinas, Georgia and Alabama.

Symptoms. The disease is first introduced in the hot-bed with infected potatoes. On the young sprouts, infection begins as a small black spot. This spot gradually involves the entire shank, which dies and turns black, whence the name, black shank (Fig. 14, b). From the hot-bed the disease is carried to the field with infected sprouts. There the symptoms on the shanks are

* Recently Dr. J. A. Elliot has shown that the supposed pycnidia and pycniospores of *Sphaeronema fimbriatum* are really asci and ascospores, hence placing it in the genus Ceratostomella. (See also *Phytopath,* 13:24, 1923.)

the same as on the sprouts in the hot-bed. Frequently also, the disease attacks the vines or foliage, in which case it is confined to intervals of a few nodes. The infected stems or foliage (Fig. 14, a) turn dark and later shrink and shrivel. Infection may also take place under ground on the newly forming or fully matured roots. From the field, black rot is carried in storage with infected potatoes. On the latter the disease appears as circular, somewhat sunken black spots the size of a silver dollar when full grown. Black rot usually gains entrance through the young rootlets, or through cracks, wounds, cuts, or bruises in the mature root, in which case the spots lose their circular outline. Black rot seldom penetrates the entire content of the potato, but only advances as far as the vascular ring, unless some other organism opens the way for its further progress. In the field and in the hot-bed, black rot lives over from year to year in the soil. In storage, the disease spreads by contact with the infected potatoes. Overheating, poor ventilation, and excess of moisture furnish ideal storage conditions for the spread of black rot. Under moist conditions, the causal organism produces an abundance of pycnidia which break through the epidermis of the potatoes. So long as the house is kept dry, and the temperature at a minimum of safety, the disease will spread very little in storage.

Black Rot Fungus Is Active on Several Hosts. The wild morning glory (*Ipomoea purpurea*) (Fig. 14, f) and the wild sweet potato (*Ipomoea pandurata*) are probably under virgin conditions of soil the most active hosts in carrying the fungus. Thus it seems probable that areas which have never grown sweet potatoes are infected with black rot because of these hosts. It would be difficult to find so-called "virgin land" that is entirely

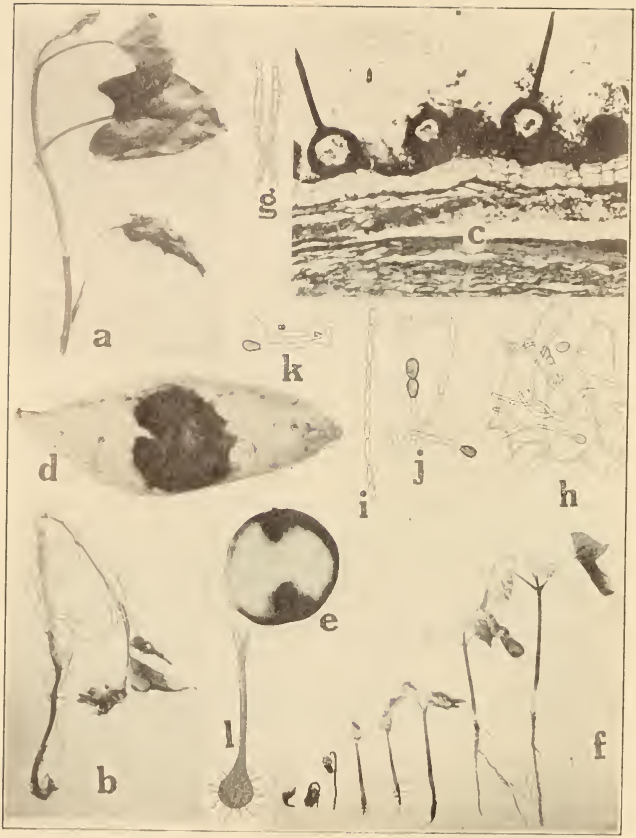

Fig. 14. Black Rot.

a. Black rot on leaf. *b.* Black shank stage on sprout. *c.* Cross-section through black rot spot to show asci of black rot organism. *d.* Black rot on mature root. *e.* Cross-section through black rot spot on root. *f.* Morning Glory seedlings; to the right, two healthy plants, to the left, six diseased with black rot. *g.* Endospore formation. *h.* Cross-section showing chlamydospores in cells of potato roots. *i.* Mycelium breaking up into spores. *j.* Same as *i*, also showing chalmydospores. *k.* Germination of conidia. *l.* Ascus. (*d* and *l* after Harter.)

free from the disease, for so many agencies are at work to assist in the broadcast dissemination of the causal organism.

Susceptible Varieties. According to Harter (36) the following varieties are susceptible to black rot: Southern Queen, White Yam, Big Stem Jersey, Yellow Jersey, Red Bermuda, Red Brazilian, Florida, White Gilke Hybrid, Vineless Pumpkin Yam, Pumpkin Yam, Eclipse Sugar Yam, Porto Rico, Triumph, Yellow Yam, Early Carolina, Miles Yam, Georgia, Pierson, Key West Yam, Nancy Hall, Red Jersey. This list includes most of the widely cultivated varieties.

The organism. Old mycelium is darkish gray, with rather close septae, and usually filled with oil globules when grown on media rich in sugar. The young mycelium is hyaline but becomes grayish with age. The hyphae, young or old, are capable of breaking up into as many cells as there are septae and each cell germinates like a spore (Fig. 14, i and j). Another stage of spore formation corresponds in part to Thielavia; namely, the spores are borne within the sheath of a terminal cell, and these are pushed out from within (Fig. 14, g). There is another spore stage consisting of olive-brown conidia. These are thick-walled, and are borne singly, by twos, or in chains. These brown conidia apparently serve as resting spores, since it takes them a much longer time to germinate. This type of spore is often found in the interior of the affected tissue, in the cells immediately below the epidermis (Fig. 14, j and h). A last stage is that of ascospores, which are borne in long-necked asci (Fig. 14, c and l). The spores are globular, minute, oozing out in a gelatinous mass, and sticking at the open end of the long neck of the ascus. Any of these spores germinate in water or in any nutritive fluid. No spore stages other than those above mentioned have been observed, in pure culture or on the host, to be connected with *Ceratostomella fimbriata.*

Bitterness of Black Rot. When roots are infected with black rot, the edible qualities are poor because of the bitter taste. This becomes more evident the longer the roots are kept in storage. Although the black rot spot is only superficial, the bitter taste in cooking is imparted to the entire root, showing that the bitter substance of black rot is apparently soluble and easily diffused into adjacent tissue. Because of this fact, every thing possible should be done not to sell black-rotted potatoes, as to do so has a bad effect on the market, and may be the means of spreading the disease to new territories. There seems no doubt but that there would be a greater demand for sweet potatoes in the cities if fewer bad ones were being sold. The abused, unsuspecting consumer has a way of retaliating in refusing to buy more.

Control. No diseased potatoes should be bedded in the hot-bed. They should be carefully selected for freedom from disease and disinfected in corrosive sublimate before planting (see p. 24). Many growers insist on bedding black-rotted potatoes and at the same time treating them with corrosive sublimate. This treatment will positively be useless if it is done on black-rotted potatoes. The treatment does not and can not penetrate the inside of the potato to reach the fungus in the tissue.

Only sprouts from healthy hot-beds should be planted out in the field. Badly infected fields should be given a rest from sweet potatoes for several years. All weeds belonging to the Morning Glory family should be destroyed. Treating the soil with fertilizers, gypsum,

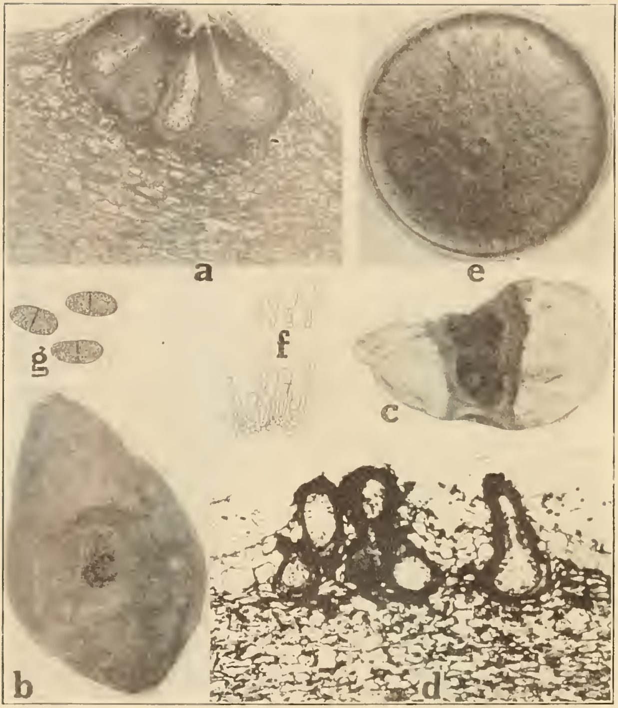

Fig. 15. Java Black Rot.

a. and *d*. Cross-section through infected root showing pycnidia on the host. *b*. Surface view of spot. *c*. Longitudinal section through *b*. *e*. Plate culture of *Diplodia tubericola*. *f*. Above and below, formation of pycniospores. *g*. Mature pycnidia. (*g* after Harter.)

lime, or sulphur will have little effect in controling black rot.

Java Black Rot

Caused by *Diplodia tubericola* (E. and E.) Taub.

Economic Importance. Java black rot, so called because it was first found in Java, and is believed to have been introduced from that country to the United States. The disease seems to be a storage trouble only, and causes some loss. It was studied by the author (95) in Delaware. The disease is apparently more common in the Southern States. It is also found in Cuba, Isle of Pines, Philippine Islands, Japan, Porto Rico, and throughout South America.

Besides the sweet potato, Java rot can also attack the dasheen (*Colocasia esculenta*). Meier (67) found that the stem rot of watermelon was caused by the same organism as that of Java rot from sweet potatoes.

Symptoms. Sweet potatoes affected by this fungus show dark shriveled patches, over which are scattered numerous pycnidia. These emit either mature one-septate dark spores heaped together, or white strings which are made up of hyaline Macrophoma spores, or both. When longitudinal sections are made through different stages of affected roots, it will be found that the fungus attacks the interior tissue, beginning at a point and gradually invading the whole of the interior of the root (see Fig. 15, b and c). The infected tissue is jet black, somewhat resembling charcoal rot. Diseased roots dry, shrivel, and become brittle.

The Organism. Diplodia tubericola, grows luxuriantly (Fig. 15, e) on numerous media. The organism produces three types of pycniospores in culture as on the host. These are: 1 Hyaline, one-celled. 2. Dark one-celled spores. 3. Dark one-septate spores (Figs. 15, f and g). In the old mummied potatoes, dark two-celled spores are common. The pycnidia (Fig. 15, a and d) of *Diplodia tubericola* on sweet potatoes are formed immediately under the epidermis, and upon maturity break through. Often they are completely buried, in which case the spores escape only after the maceration or disintegration of the host. Infection seems to be favored by high temperature and moisture in the storage house. The rot works slowly, requiring four to eight weeks to completely destroy the infected potatoes.

Control. Since Java rot seems to be a storage disease only, it should require but little trouble to be kept in check. Infected material should be destroyed by fire. The storage house should be carefully cleaned and disinfected immediately after the storage season (see p. 222).

CHAPTER XI

SPECIFIC DISEASES (*Continued*)

Septoria Leaf Spot

Caused by *Septoria bataticola* Taub.

Economic Importance. Septoria leaf spot is a field disease only. It usually occurs when the vines are full grown; hence it really causes little damage. It is prevalent in New Jersey, Delaware, Maryland, Virginia, Iowa and in other states where sweet potatoes are grown.

Symptoms. This disease is characterized by minute white spots, ranging from one-eighth to one-third inch in diameter (Fig. 16, a). These are chalky white, bordered by a brown area, and upon close observation are found to bear a few minute pycnidia.

The Organism. The fungus grows well (Fig. 16, b) on moist media. The pycnidia on the host vary from one in the center to a few scattered ones in spots, mostly circular, chalky white bordered by a brown area, and covering the leaf sparsely or thickly. The pycnidia are imbedded under the epidermis with open mouths protruding, or free, readily falling out; the spores are hyaline, vermiform, curved to straight.

Control. The disease is not serious enough to warrant methods of control.

Trichoderma Rot

Caused by *Trichoderma Koningi* Oud., or *Trichoderma lignorum* (Tode) Harz.

Economic Importance. Trichoderma rot is a storage rot of minor importance. It has been found by Cook and Taubenhaus (13) in Delaware on sweet potatoes infected with ring rot. Trichoderma has since frequently been isolated from rotted potatoes in Texas. It probably may be found in other states.

Symptoms. The symptoms of the disease may be given as follows: In their earliest stages the spots are circular and of a light brown color with a tendency to wrinkle (Fig. 17, c to f). The flesh is hard and water-soaked, brown in color, with a black zone at point of contact between the healthy and diseased tissue. The spot enlarges in all directions and eventually destroys the entire root. When the decay is well advanced, a very luxuriant white mycelial growth is formed on the surface. Spores are produced very sparingly on this growth when in contact with the decayed tissue, but very abundantly on that part of the mycelium which has spread over the healthy surface. The symptoms produced by *T. lignorum* are very similar to those of *T. koningi,* except that a deeper brown zone separates the diseased from the healthy tissues.

The Organism. *Trichoderma lignorum* is common and widely distributed on decaying wood and various other substances. *Trichoderma koningi* was originally isolated from the soil by Oudemans (76) and is still looked upon as a soil organism. The spores of *T. lignorum* are spherical while the spores of *T. Koningi* are elliptical. In germinating the spores of *T. Koningi* form one to two germ tubes, while the spores of *T. lignorum* in germinating send out two or three germ tubes. The mycelium of *T. koningi* is distinguished by its great abundance of chlamydospores while the *T. lignorum* very rarely produces chlamydospores (Fig. 17, i, j, k). In very old cultures of *T. koningi* the chlamydospores are frequently free and in a state of germination. What appear to be haustoria were seen in tissue affected with *T. koningi.* The conidophores of the two organisms do not show distinguishing characters (Fig. 17, k). When grown on different synthetic media the two organisms show different growth-characteristics (Fig. 17, a and b).

Control. The disease is undoubtedly brought from the field to the storage house with bruised potatoes. Care in that direction will be very helpful. All other precautions necessary to control soft and ring rot, will also keep the Trichoderma rot in check.

Botrytis Rot

Caused by *Botrytis cinerea* Pers.

Economic Importance. Botrytis rot is of little economic importance. It may generally be found in storage houses where the temperature is rather low. Botrytis rot has been reported but once by Harter (51), and the extent of its distribution as a sweet potato disease is not known.

Symptoms. The decay produced is of a grayish, soft, watery nature (Fig. 19, n). Infected sweet potatoes have a starchy odor, and when broken, the tissue pulls out in strings. No methods of control are known.

Soil Stain or Scurf

Caused by *Monilochaetes infuscans* E. and H.

Economic Importance. Soil stain is not a disease to be feared in the sense that it may produce a direct rot in the mature roots; nevertheless, it is economically important. Growers whose lands are badly infected assert that stained roots keep better in storage. Others find consolation in saying there is no such thing as stain, the dark color of the skin being merely a varietal characteristic. The fact remains, however, that many eastern markets discriminate against stained roots. In years of overproduction the New York market refuses stained roots. The Western buyers, on the contrary, are lax on this point; otherwise, many growers in the United States would be forced to cease producing sweet potatoes for want of a market. Soil stain is prevalent in the following states: New Jersey, Delaware, Maryland, Virginia, North Carolina, Ohio, Illinois, Iowa, Kansas, Texas and, in fact, wherever sweet potatoes are grown. Soil stain is more prevalent in the heavy black soils, and in soils which were heavily manured, though it occurs to some extent in the sandy and sandy loam soils.

Symptoms. Soil stain is primarily a field trouble where it is introduced from the hot-bed with sprouts from infected seed sweet potatoes. It is also spread to some extent in the storage house where it is first brought in with infected potatoes from the field. Soil stain is characterized at first by small, circular, deep-clay-colored spots on the surface of the sweet potato root. These spots occur singly, but usually there are several in a given area. When very numerous, the spots coalesce, forming a large blotch, which sometimes takes the form of a band or may cover the entire root (Fig. 16, c and d). Soil stain is particularly conspicuous on the white-skinned varieties such as the Southern Queen. Here the color of the spots is that of a deep black clay loam. On the darker skinned varieties, the color of the spots is not so conspicuous. Soil stain is a disease of the underground parts of the plant. The vines and foliage are never attacked as long as they remain free from the soil. However, when these are covered, the petioles as well as the stems become infected. The disease penetrates the host to the depth of the epidermis and it may be readily rubbed off by the finger nail.

After several months of storage, badly affected roots become a deep brown, which greatly contrasts with non-infected sweet potatoes. Occasionally, badly stained roots seem to be subject to more rapid drying and shrinking. This, however, is not often the rule. Usually soil stain is very prevalent in overheated storage houses. It may be, therefore, that the rapid shrinkage is due to the overheating and not to the effect of the disease itself.

The Organism. Monilochaetes infuscans was studied by Halsted (27), Harter (38) and by the author (99). The surface growth of a colony resembles that of species of Alternaria and some species of Cladosporium, but differs from these by its restricted slow growth (Fig. 16, g). The surface of the colony of *M. infuscans* has an ashen color, which is also the general appearance of the fruiting. The fungus grows better on vegetable plugs and is at its best on steamed onion and celery stalks. The aerial mycelium is branched, separate, and hyaline when young; with age it turns gray, then black, and becomes filled with oil globules. The submerged hyphae are made up of smaller cells which in old cultures swell and take on the appearance of chlamydospores. The conidiophores are distinct from the mycelium (Fig. 16, f) and do not seem to arise in clusters, but are formed singly. They are erect, unbranched, and made of closely septate dark-celled mycelium, the base of which rests on one or two smaller ones (Fig. 16, e). Generally the measurements of the conidiophores vary with the medium used. The host, too, seems to have a determining influence.

The spores are borne in distinct chains. In a pure culture, the chains break up very readily when moistened and pressed down with a cover glass. The spore chains break immediately when moistened with alcohol, oil, or any other liquid (Fig. 16, f). The chains of spores do not appear to be held together with any kind of mucilage. At first, the protoplasm of the tip of the conidiophore is seen to round up; then a minute bud pushes out and increases in size until a mature spore is developed, which is left standing at the tip of the conidiophore (Fig. 16, f). All the succeeding newly formed conidia are borne at the tip of the conidiophore, so that the oldest conidium stands at the farthest end of the chain (Fig. 16, f). These chains are made up of ten to twenty-eight conidia. A distinct characteristic of the latter is that they are always guttulate, irrespective of the medium used. In some cases the conidia in pure culture appear to be massed in "pockets" around the tip of the conidiophore, as in species of Gloeosporium or Fusarium. However, a close examination will show that this is not a definite characteristic of the fungus, since the least disturbance will cause the chains of conidia to break up. In so doing they invariably cluster around the conidiophore, grouping themselves in various ways. This is observed only when the fruitings of the fungus are seen in a dry state. However, when placed

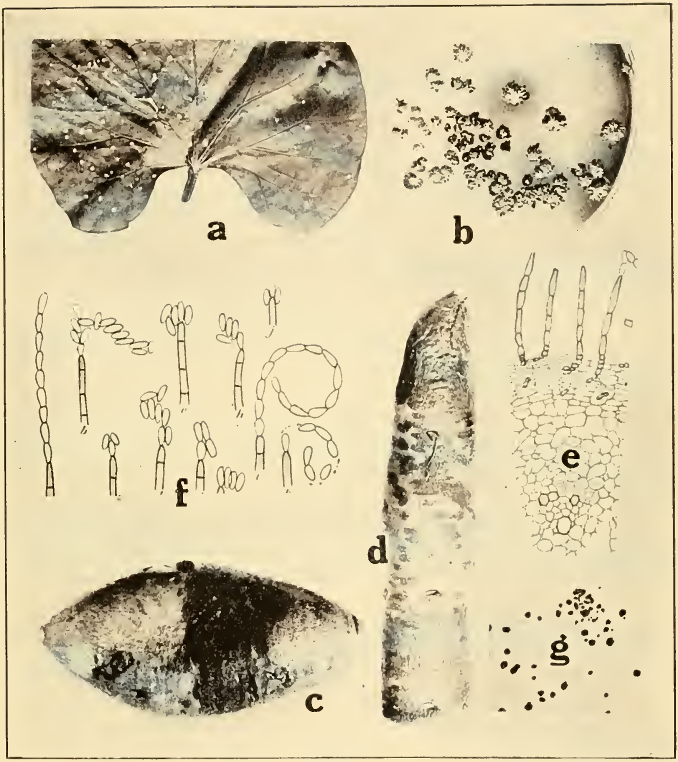

Fig. 16. Soil Stain.

a. Septoria leaf spot. *b*. and *g*. Pure cultures of *Monilochaetes infuscans*. *c*. and *d*. Soil stain spots on roots. *e*. Cross-section through sweet potato root to show the growth of the soil stain fungus on the host. *f*. Stages in the formation of conidia of *M. infuscans*.

in a drop of water or in any other liquid, the chains of spores break up and scatter irregularly over the liquid. The spores (conidia) are one-celled, hyaline, with a greenish tinge, but never dark or brown. Sometimes a tube is produced at the tip of the conidiophore which later bears spores. Broken-off mycelial cells are also capable of germinating. The spores readily germinate in water or in any nutrient medium.

An attempt was made by the author to determine whether *M. infuscans* would also cause a rot of the interior of the sweet potato root. Inoculations with pure cultures of the fungus in slits made with a sterilized and cooled scalpel showed the organism incapable of causing a rot of the root.

Control. Soil stain is carried directly with the seed sweet potatoes. As far as possible, stained potatoes should not be used for bedding, because the roots may also be infected with black rot, and yet the latter will be obscured by the blackened skin. Potatoes with but few and scattered stain spots may be bedded in the hotbed, provided they are disinfected with corrosive sublimate (see p. 24).

In the field, infected soils should be avoided if possible and should receive no manure. According to Harter (38), the following varieties are susceptible to soil stain: Eclipse Sugar Yam, General Grant Vineless, Florida, Nancy Hall, Yellow Yam, Miles Yam, Red Brazilian, Red Bermuda, Japan Brown, Dahomey, Yellow Strasburg, Pierson, Key West Yam, Red Gilke Hybrid, Vineless Pumpkin Yam, Pumpkin Yam, Porto Rico, Triumph, Vineless Yam, Southern Queen, Big Stem Jersey, Yellow Jersey, and Early Carolina Creole. It is also likely that soil stain occurs on other varieties of sweet potatoes.

In storage, proper care should be given to heating and ventilation. The disease is always worse in damp, overheated, and poorly ventilated storage houses.

Alternaria Rot

Caused by Alternaria sp.

Among the many organisms which produce storage rots at low temperatures may be mentioned a species of Alternaria. It produces a firm, moist rot (Fig. 19, o), the tissue turning brown, and then gradually darkening, but never becoming black. The infected potato breaks easily, and the parts separate without the formation of strands.

Vine Wilt, or Stem Rot, Blue Stem

Caused by *Fusarium hyperoxysporum* Woll., *Fusarium batatatis* Woll.

Economic Importance. Stem rot in some states is equally as important as black rot (see p. 141) or even pox (see p. 107). The losses vary from 2 to 90 per cent. The disease is prevalent in New Jersey, Delaware, Maryland, Virginia, Illinois, Iowa, Kansas, Alabama, Arkansas, Missouri, North Carolina, Ohio, Georgia, Oklahoma and Mississippi. In many of the Southern States, the disease is usually not serious, as some of the Southern varieties, the Nancy Hall excepted, seem to be more resistant. The disease was studied by Halsted (27), Stevens (89), Harter (32), McClintock (64), and the author (97).

Symptoms. The first indication of vine wilt in the field is a slight paleness of color. The leaves become

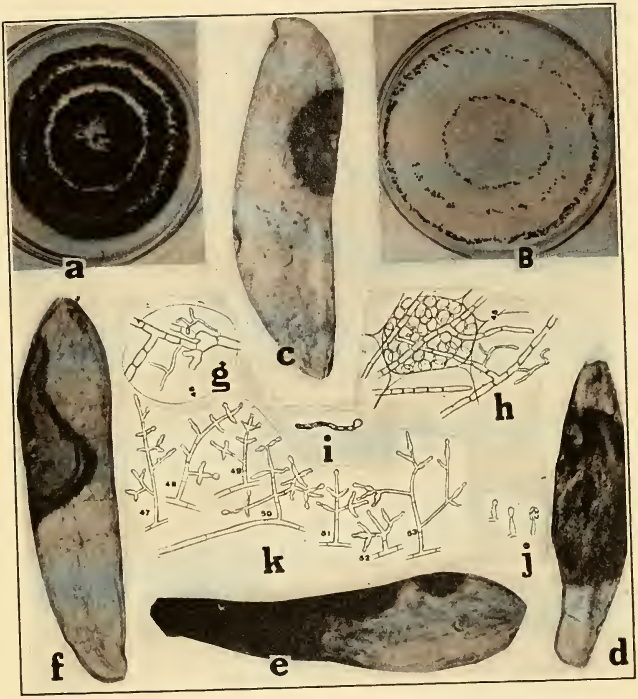

FIG. 17. TRICHODERMA ROT.

a. Plate cultures of *Trichoderma* *lignorum*. *b*. Plate culture of *T. koningi*. *c*, *d*, and *e*. Sweet potatoes artificially inoculated with *T. koningi*. *f*. Sweet potato inoculated with *T. lignorum*. *g*. Cell of sweet potato root tissue invaded with mycelium of *T. koningi*. *h*. Same as g. *i*. Germinating spores of *T. koningi*. *j*. Spore formation of *T. koningi*. *k*. Conidiophores of: to right, *T. koningi;* to left, *T. lingorum*.

dull and then yellowed between the veins and puckered. This is followed by a wilting of the vines in the hill. Usually the tip leaves on the vines are the first to show the effects of the wilt. As a rule, the old basal leaves drop off if the vine becomes infected. Frequently but one or two vines in the same hill will remain alive while all the others will die. Usually, however, all the vines die off and, soon after, new shoots start out from the base of the plant (Fig. 18, b and c). In this case the vines only and not the roots are killed. Frequently infected hills straggle along and even produce potatoes, but these are usually small (Fig. 18, e) and are often unintentionally used for seed.

The Organisms. The causal organisms of vine wilt invade the vascular bundles of the vines and roots. When the tip end of an infected potato is cut with a sharp knife, the vascular bundles will be found to be brown (Figs. 18, a, d, e and 19, a). When an infected sweet potato vine is split lengthwise, the inside too will be brown to dark; whereas a healthy vine will have a white interior (Fig. 18, d).

In the hot-bed, vine wilt is manifested in the same way as in the field. Diseased plants may be detected by a faint purplish tint of the stem, and the yellow discoloration of the leaves. The organisms, *Fusarium batatatis* Woll., in pure culture produce conidia, sporodochia, and pionnotes; the Conidia (Fig. 19, c and d) are mostly three-septate, rarely four- or five-septate. The chlamydospores are brown and thick. The blue sclerotia have a blister-like appearance. *Fusarium hyperoxysporum* Woll. (Fig. 19, a) resembles *F. oxysporum* but differs from it by having perfect pionnotes. Both *F. batatatis,* and *F. hyperoxysporum* (Fig. 19, c and d) were originally described by Wollenweber (116).

Control. It has been indicated that the causal organisms enter the roots where they remain in the fibrovascular bundles. Such roots when harvested and put in storage do not rot. Early in the spring, when these infected potatoes are bedded in the hot-bed, the disease will infect the sprouts (Fig. 18, a) and thence will be carried to the field. It is, therefore, of extreme importance to secure only healthy seed sweet potatoes. When one is in doubt, the tip end of the potato should be cut off with a sharp knife, and potatoes with dark brown fibers should not be bedded. These may be cooked and fed to stock. Before being bedded, the potatoes should be disinfected in corrosive sublimate (see p. 24). This treatment will not kill the vine wilt fungus within the potato, but will destroy any spores which may adhere on the surface.

The sand in the hot-bed should also be changed every year. Fresh sand should be procured from that part of the farm which never grew sweet potatoes before. Each year, the wooden frame work of the hot-bed should be disinfected by wetting it with a solution of one pint of formaldehyde in thirty gallons of water, or with a solution made up of five pounds of blue stone (copper sulphate) dissolved in fifty gallons of water. This treatment should be given twice at an interval of twenty-four hours.

The application of lime, gypsum salt, or any other fertilizer to the soil with a view of warding off vine wilt will be of no value. Where vine wilt is prevalent, seed from vine cuttings are preferred. The cutting should of course be made from healthy vines, and planted on healthy ground. In infected regions, crop rotation should be practiced, and the land given a rest from sweet potatoes for at least three or four years.

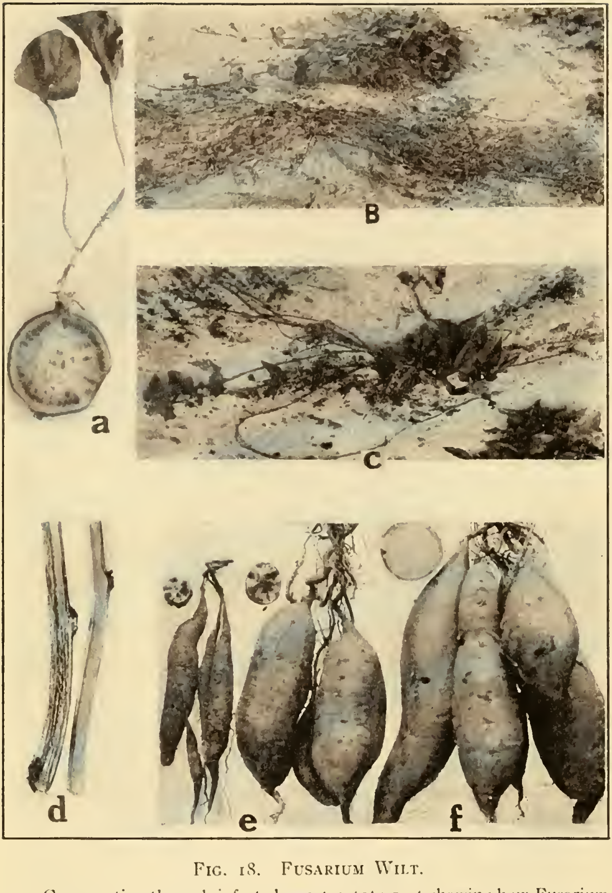

FIG. 18. FUSARIUM WILT.

a. Cross-section through infected sweet potato root showing how Fusarium wilt is communicated to the young sprout through the fibro-vascular bundles of the mother root. *b*. Below, sweet potato hill killed by Fusarium wilt; above, healthy hill. *c*. Like *b*, but new sprouts originating from center of hill. *d*. Longitudinal section for comparison: to left, diseased stem; to right, healthy stem. *e*. Two sweet potato hills from infected plants. *f*. Sweet potato hill from healthy plant.

Harter and Field (44) have shown through actual inoculation, that certain Southern varieties possess considerable resistance to wilt. These are the Dahomey, Red Brazilian, and Yellow Strasburg. However, the growing of these varieties other than in the Southern States could not be advocated. A variety which may be prolific in one region may be a very poor yielder when introduced in a new locality. The Yellow Jersey, for instance, produces a fine potato in New Jersey or Delaware, but greatly deteriorates when grown in the South. Moreover, the market requirements are to be considered. The Northern markets which prefer a dry, mealy sweet potato will not readily accept the yam type of the South. Hence, methods of control based on resistant varieties offer little promise. The only solution is the development of resistant local strains by selection. This, however, has not shown much promise in the past.

Surface Rot

Caused by *Fusarium oxysporum* Schl.

Surface rot of the sweet potato is generally a storage trouble. It appears as nearly circular, brownish, somewhat sunken spots on the surface of the stored roots. Sweet potatoes thus affected shrink, especially at the margin of the spots. In severe cases the entire root dries up, becoming unfit for eating purposes.

According to Harter and Weimer (48) infection takes place at digging time during wet weather or early in the storage period under low temperature conditions.

Control. As far as possible digging should be done during dry weather. Furthermore, the roots should not be brought in wet to storage, nor the storage house permitted to cool off during the early process of sweating.

Other Fusarium Rots

It has been shown by Harter (51) that *Fusarium culmorum* Woll. and *F. accuminatum* E. and E., may produce a storage rot under low temperature conditions. The symptoms are a slow decay, the affected tissue becoming spongy but not watery. At first the decayed tissue is a faint reddish-brown which later turns carmine-red, or maroon. As the potato dries out and becomes mummified, the deep color is replaced by a beautiful pink.

The following Fusaria isolated from sweet potatoes do not seem capable of inducing any rot in storage: *F. batatatis* Woll.; *F. hyperoxysporum* Woll.; *F. radicicola* Woll.; *F. caudatum* Woll.; *F. solani* (Mart.) Sacc.; *F. incarnatum* (Rob.) Sacc.; *F. orthoceras* Appel and Woll.; *F. orthoceras var. triseptatum* Woll.; *F. oxysporum* Sch.; *Nectria ipomoeae* Hals.

CHAPTER XII

SPECIFIC DISEASES (*Continued*)

Epicocum Rot

Caused by Epicocum sp.

Epicocum rot cannot be considered of much economic importance. It is found under low temperature conditions in the storage house. The rotting is slow, the affected tissue is firm, at first slightly yellowish, then reddish-brown (Fig. 19, l).

Charcoal Rot

Caused by *Sclerotium bataticola* Taub.

Economic Importance. Charcoal rot is a storage rot only, distributed throughout the United States and elsewhere. It has been collected by Harter (51) from specimens of sweet potatoes received from Japan and other foreign countries. The same disease is also known to attack green peppers.

Symptoms. Charcoal rot is commonly mistaken for black rot. While black rot produces only superficial spots on the roots, and does not produce a rot of the entire root, charcoal rot is a disease that penetrates the entire root. The parasite does not produce surface spots, but turns the interior tissue into a black charcoal mass (Fig. 19, g) caused by the formation of minute, black sclerotia. With the exception of drying and slight shrinkage, unless the skin is bruised, showing the blackened contents, there are no external symptoms to distinguish this disease. It can be recognized only when the roots have been completely invaded and broken open.

The Organism. *Sclerotium bataticola* was thought by Halsted (27), Burnette (7), Townsend (107), Wilcox (114) and Duggar (17) to be a stage of the black rot fungus, *Ceratostomella fimbriata.* However, work by the author (95) has shown that *Sclerotium bataticola* was a distinct organism, and in no way related to *Ceratostomella fimbriata.* The Sclerotia are jet black, and minute; they have a smooth exterior, made up of anastomised black hyphae; the interior is light to dark brown in color, made up of free, thick-walled, cortical, hyphal cells; sclerotia vary much in shape, being spherical, oval, oblong, elliptical, curved, or even forked; they also vary in size (Fig. 19, i to k), are abundant throughout the entire root of the host, and are parasitic on living roots of sweet potato.

Control. Charcoal rot is prevalent in overheated and poorly ventilated storage houses. The method which will control soft rot (see p. 135) may also control charcoal rot.

Cottony Rot

Caused by *Sclerotium rolfsii* Sacc.

Economic Importance. Cottony rot is a trouble that occurs primarily in hot-beds, where it often destroys ten to forty per cent of the sprouts. It is met with frequently in the field and occasionally in storage. Cottony rot also attacks corms of *Colocasia esculenta,* of *Xanthosoma sagittifolium,* and a large number of other hosts.

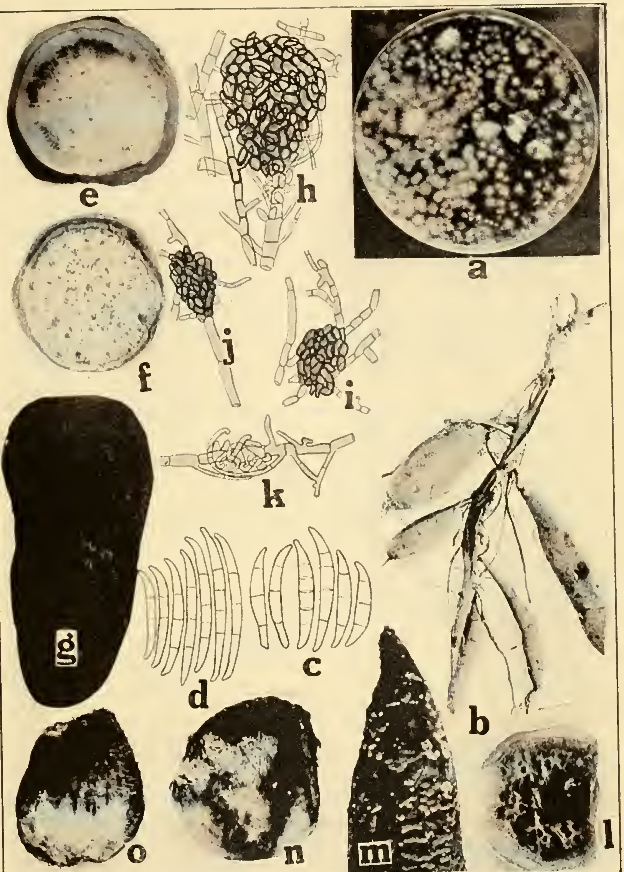

FIG. 19. VARIOUS DISEASES.

a. Pure culture of Fusarium isolated from diseased sweet potato root. *b*. Young infected hill showing bursting of the main basal vine and root due to the wilt disease. *c*. Spores of *Fusarium batatatis*. *d*. Spores of *F. hyperoxysporum*. *d*. Cross-section of sweet potato root showing infection at the fibro-vascular bundles. *f*. Mucor rot. *g*. Charcoal rot. *h*. to *k*. Stages in Sclerotia formation of *Sclerotium bataticola*. *l*. Epicocum rot. *m*. Penicillium rot. *n*. Botrytis rot. *o*. Alternaria rot. (*f*, *l*, to *o*. after Harter.)

Symptoms. In the early stage of infection, the foot of the sprout becomes soft, watersoaked, and covered at the exterior by a cottony white growth of fungus mycelium. Later numerous sclerotia the size of a mustard seed are formed all over the dead sprouts. From the plant, the fungus works down into the mother potato causing it to rot slowly. In storage, cottony rot is not common, but occasionally found there. Affected potatoes become punky and dry. If a freshly infected potato is cut open and placed in a moist chamber, the mycelium of the causal organism will grow out profusely on the walls of the glass.

The Organism. Sclerotium rolfsii, as far as we know, is a sterile fungus. It reproduces by means of sterile mycelium and sclerotia, the latter of which may live over in the soil from year to year. As soon as the disease makes its appearance in the hot-bed, the affected area—plants and soil—should be carefully lifted out with a spade. The water should be withheld and the hot-bed given plenty of ventilation and sunlight. Treating the seed sweet potatoes with corrosive sublimate (see p. 24) before bedding will also be helpful.

Texas Root Rot

Caused by *Ozonium omnivorum* (Pam.) Shear

Economic Importance. Texas root rot is primarily a field trouble, found in the heavy, waxy lands. The disease, so far, is restricted only to Texas, New Mexico, Oklahoma, and Arizona, where it also attacks the cotton, okra, cowpeas, beans, apples, pears, grapes, mulberry, castor beans and many other economic crops. The loss from Texas root rot varies with the season. Frequent showers during July and August greatly favor the disease.

Symptoms. Viewed from afar, an infected field appears promising. It is only during harvesting that the extent of loss is appreciated. Not all hills are destroyed, since the disease works in irregular spots, the size of which will vary from that of a single hill to a quarter of an acre or more. The causal organism usually attacks the plant at its crown or through the underground parts and works up a few inches to the main stem. The vines die only at the invaded area, as new roots are sent out at the nodes. During digging, there are usually very few or no potatoes at each diseased hill. The affected roots are firm, soggy, and brown. The few sound potatoes which may be obtained from a diseased hill will not keep very long, but will usually rot from the entrance of secondary organisms.

The Organism. Ozonium omnivorum is propagated from year to year mostly by its vegetative mycelium which winters over on living roots of sweet potato, cotton, okra, or on perennial susceptible weeds. The sweet potato, especially, is a favorable host on which to winter over, as the causal organism is seen to grow luxuriantly on the remaining living roots in the soil during any time in the winter. The mycelium of *O. omnivorum* is brown, septate, and branched, the branches being nearly at right angles. The hyphae may frequently be seen on the surface of the dead stems or roots as grayish wefts of mycelial strands. These strands are made up of interwoven mycelial threads. The causal organism occasionally produces conidia in the field and when grown in pure culture in the laboratory. So far, every effort by the author to germinate these conidiospores has failed. For this reason, it is difficult as yet to ascribe the function of these spores in the life cycle of the causal organism.

Control. Where root rot is prevalent, sweet potatoes should not be planted on heavy clay soils, but only on sandy or sandy loams. Deep clean cultivation, aeration of the soil, and rotation with grain crops in which clean culture is practiced will help to keep the disease in check.

Rhizoctonia Root Rot

Caused by Rhizoctonia sp.

Rhizoctonia root rot is a hot-bed disease. It frequently occurs where the soil in the frame was fertilized heavily with manure. The disease is manifested as deep brown lesions or cankers at the foot of the plant. These lesions are often deep enough for the affected sprouts to break in two when touched or when being watered.

Control. Rhizoctonia root rot may be kept in check by filling the hot-bed with clean sand instead of heavily-manured, rich clay soil. As a further precaution, the seed sweet potatoes should be treated with corrosive sublimate.

Other Fungi

Several organisms have been isolated by Harter (51) from rotted sweet potatoes which were as follows: *Nectria ipomeae* Hals., which grows only on sweet potatoes rotted by other organisms; *Fusarium caudatum* Woll., which is not parasitic. Among others in which parasitism has not been tested out may be mentioned the following: Zygorhynchus sp., Penicillium sp. (Fig. 19, m), Melanospora sp., Trichosporium sp., Ceratostoma sp., Sporotrichium sp., Pestalozzia sp., *Aspergillus* *niger* Von Tiegh, *Fusarium vasinfectum* Atk., Cephalothecium sp., *Neosomospora vasinfectum* Atk., *Verticillium cinnabarinus,* Acromoniella sp., Macrosporium sp., Actinomyces sp., and others.

Non-Parasitic Diseases

Hollow Heart

Caused by drought

Hollow heart is a new disease of the sweet potato. As far as is known to the author, this trouble has not been reported before in literature. It was especially prevalent in Texas during 1918. The summer in that year was unusually dry, the sweet potatoes had made scant growth, and the yields were below the average. The sweet potatoes when harvested were practically cured. When the crop was put in storage, the farmers again put it through the regular curing process, in which case more moisture was given off. Specimens when received and broken open, were found to be hollow in the center, and the flesh dry and pithy. When cross-sections of various potatoes were made, it became evident that the trouble resided in the fibro-vascular bundles, which were cracked and disintegrated. As the potatoes were cut farther down, the cracks became more and more prominent and on reaching the center, the heart of the root was found to be hollow (Fig. 20, a). Numerous cultures of the potatoes affected with hollow heart yielded no organism. With the Irish potato, hollow heart is attributed to prolonged drought, followed by excessive rain. With the sweet potato, hollow heart seems to be favored by a prolonged dry season followed by the usual curing in storage.

Control. It is at once evident that, during dry seasons, the roots contain naturally less moisture when harvested. Under these conditions, the curing period should be short, and the potatoes subjected to no high temperature which is conducive to more rapid sweating.

Net Necrosis

Cause Unknown

Net necrosis in the sweet potato resembles the same disease in the Irish potato. The symptoms are practically alike in both. The disease appears as dark brown streaks at the vascular bundles (Fig. 20, b), and may often be mistaken for the browning brought about by vine wilt, *Fusarium batatatis,* and *F. hyperoxysporum.* These streaks originate at the point of attachment to the vine. Frequently it may not be detected at time of digging, but the streaking will develop later in storage. The cause of net necrosis is not known. Research along this line is very desirable.

Mosaic

Cause Unknown *

This disease is as yet of little economic importance. It was first described by Ensign (22) and by Rosen (85) in Arkansas. The writer has seen this disease in

* Recently, Ray Nelson (*Phytopath,* 13:9, 1923) has indicated that mosaic in plants is probably induced by protozoa, apparently trypanosomes, or closely related to this genus.

Georgia and in Texas, but not in sufficient quantity to attract the general attention.

The symptoms are characteristic of mosaic. The affected foliage is mottled, dwarfed, and poorly developed. Diseased hills produce few or no potatoes.

Control. The disease may be eradicated if care is taken not to use seed (roots) from infected hills. These should be pulled out and destroyed. Two successive seasons of careful roguing of diseased plants will probably eliminate all infected seed.

CHAPTER XIII

INSECT AND OTHER PESTS

In a work of this nature, consideration of the important insect pests of sweet potatoes can not be overlooked.

Sweet Potato Weevil

The information on the sweet potato weevil is taken from Chittenden (12). The losses from the weevil often vary from 25 to 50 per cent and in numerous cases the crop is a total failure. In 1917, in Texas the sweet potato crop was valued at $9,000,000.00. The loss from the weevil was 20 per cent or $1,800,000.00 for that year. In Louisiana with a crop valued at $5,000,000.00, losses in 1917 amounted to about 12 per cent or $600,-000.00, Florida, with a $4,000,000 crop lost about $400,000.00.

Sources of Infestation. According to Chittenden the principal infestation comes through over-wintered weevils. These live over winter, in storage houses on stored sweet potatoes, and on roots left in the field after digging. The weevil is further carried on cuttings, vines, draws, and slips, and especially seed roots as well as on morning glories.

Distribution. The weevil is known to occur in Florida, Louisiana, Texas, Georgia, Mississippi and Alabama. Should it ever be found in Tennessee, it will spread rapidly to North and South Carolina, Missouri, Kentucky, Oklahoma and Arkansas. Unless drastic measures are taken by both State and Federal Governments, the weevil may spread to every state in the Union where this crop is grown. The weevil is also found in Cochin China, Mauritius, India, Asia, Africa, Formosa, Madagascar, Australia, Hawaii, Guam, West Indies, Cuba, Porto Rico, Haiti, Grand Cayman, Jamaica and British Guiana.

Food Habits and Nature of Injury. The sweet potato weevil feeds on the sweet potato, the yam, the goat's-foot morning glory (*Ipomoea pes-capra*), and other plants of the Morning Glory family.

The weevil feeds on the sweet potato leaves, vines, stalks and roots. The female weevil lays her eggs in the vines and in the stalks or crowns as well as in the roots and continues to work and breed in the roots in storage. The larvae, on hatching, feed and tunnel through the vines to the roots, in which case the vines are killed and the roots become badly riddled and filled with excreta which imparts such a bitter taste that even swine will not eat them. Frequently, enough eggs are deposited at the base of the vine so that when the larvae hatch, they completely girdle the plant. The sweet potato weevil has a pair of delicate looking wings which are, however, little used; hence it can not be supposed that its spread is due primarily to flight. Its spread is largely made possible through the shipment of infested seeds and plants.

Control. All states in which sweet potato weevil are known to occur should adopt quarantine measures. Such are already in force in Georgia, Florida and Alabama. In Texas, the quarantine legislation prohibits the transportation of sweet potato plants, draws, and slips from a weevil-infested locality to regions where the insect is unknown. For the further prevention of the spread of this pest it is necessary to clean up infested fields as promptly as possible and to destroy all vines and all other remnants. Then the ground should be deeply plowed and kept free from volunteer sweet potatoes or morning glory vines. It is a good policy to have the field gone over by hogs after harvesting, and this will usually clean up all the culls and strings. A further control measure is crop rotation. Corn, cotton, tobacco, Irish potatoes or any other truck crop except sweet potatoes should be planted after sweet potatoes. All new fields should be planted far from the original seed bed.

Where sweet potatoes are only lightly infested by the weevil, they are sometimes disinfected and the insects destroyed by carbon disulphide evaporated in tight receptacles. Where this is done, however, the roots usually lose their germinating powers and fail to sprout, or, as is often the case, may rapidly decay. From our present meager knowledge it is, therefore, not advisable to fumigate sweet potatoes. Spraying the foliage with one pint of zinc arsenite in 40 gallons of water will reduce the damage from weevils sometimes about 80 per cent. Where this is used, fifteen pounds of cactus solution should be added to each 40 gallons of the spray mixture to help it stick and spread better. The spray should be applied as soon as the first weevils appear. A second application should also be made, and a third one in case of heavy infestation. Before the plants are set out in the field, they should also be dipped in a solution composed of one pound of lead arsenate and 10 gallons of water.

The best method to prevent the spread of the weevil is legislation. The following samples of proclamations by the United States Secretary of Agriculture are self-explanatory.

Sweet Potato and Yam Quarantine (Foreign)

Notice of Quarantine No. 29

The fact has been determined by the Secretary of Agriculture, and notice is hereby given, that certain injurious insects, new to and not heretofore widely prevalent or distributed within and throughout the United States, namely, sweet potato weevils (Cylas spp.), occur in Cuba, Haiti; Jamaica, British Guiana, India, China, Cochin China, Friendly Islands, Sumatra, Formosa, Philippine Islands, Australia, Madagascar, and Liberia, and the sweet potato scarabee (*Euscepes batatae*), occurs in the Barbados, Antigua, Nevis, St. Vincent, St. Kitts, Jamaica, Brazil, New Zealand, and Guam.

Now, therefore, I. ....Secretary of Agriculture, under the authority conferred by the act of Congress approved August 20, 1912, known as the Plant Quarantine Act (37 Stat., 315), do hereby declare that it is necessary, in order to prevent the introduction into the United States of the sweet potato weevils and the sweet potato scarabee mentioned above, to forbid the importation into the United States from the above-named and all other foreign countries and localities of all varieties of sweet potatoes and yams (*Ipomoea batatas* and Dioscorea spp.).

On and after January 1, 1918, and until further notice, by virtue of said act of Congress approved August 20, 1912, the importation for any purpose of any variety of sweet potatoes or yams (*Ipomoea batatas* and Dioscorea spp.) from the above-named and all other foreign countries and localities is prohibited, except for experimental or scientific purposes by the Department of Agriculture; provided, that the entry for immediate export, or for immediate transportation and exportation in bond, of sweet potatoes and yams (*Ipomoea batatas* and Dioscorea spp.) of all varieties designated in this quarantine may be permitted in accordance with the regulations governing such entry for immediate export, or for immediate transportation and exportation in bond, promulgated by the Secretary of Agriculture, October 20, 1917.

This notice of quarantine shall not apply to the Territories of Hawaii and Porto Rico.

Done in the District of Columbia this 18th day of December, 1917. Witness my hand and the seal of the United States Department of Agriculture.

(Signed) ....

SECRETARY OF AGRICULTURE.

Sweet Potato and Yam Quarantine (Domestic)

Notice of Quarantine No. 30

The fact has been determined by the Secretary of Agriculture, and notice is hereby given, that two injurious insects, namely, the sweet-potato weevil (*Cylas formicarius*) and the sweet-potato scarabee (*Euscepes batatae*), new to and not heretofore widely prevalent or distributed within and throughout the United States, exist in the Territories of Hawaii and Porto Rico.

Now, therefore, I, ... Secretary of Agriculture, under the authority conferred by the act approved August 20, 1912, known as the Plant Quarantine Act (37 Stat., 315), do hereby quarantine said Territories of Hawaii and Porto Rico, and do prohibit, by this Notice of Quarantine No. 30, the movement from the Territories of Hawaii and Porto Rico into or through any other Territory, State, or District of the United States of all varieties of sweet potatoes and yams (*Ipomoea batatas* and Dioscorea spp.)

On and after January 1, 1918, and until further notice, by virtue of said act of Congress approved August 20, 1912, it shall be unlawful to move any sweet potatoes or yams (*Ipomoea batatas* and Dioscorea spp.), of any variety from the Territories of Hawaii and Porto Rico into or through any other Territory, State, or District of the United States, regardless of the use for which the same are intended.

This quarantine shall not apply to the movement by the United States Department of Agriculture of the plant products named for experimental or scientific purposes.

Done in the District of Columbia this 18th day of December, 1917.

Witness my hand and the seal of the United States Department of Agriculture.

(Signed) ....
Secretary of Agriculture

Flea Beetle

(*Chaetocnema confinis* Cr.)

The sweet potato flea beetles are small, brownish-black insects. They eat their way through the leaves forming small channels. As a result, many of the leaves of the young plants are killed, turn brown, and rot. They are especially severe on low land, and where sweet potatoes are grown a number of years on the same land.

Control. Sanderson recommends dipping the plant before putting it out in the field in a solution of arsenate of lead. An application of ordinary Bordeaux mixture will act as a repellant.

Tortoise Beetles

These are small, brilliant, golden colored beetles, belonging to the family Cassidae. They are beautiful little insects with a peculiar power of changing color. Some of the species even appear like drops of molten gold. The beetles usually feed on the foliage, causing round holes. The leaves are often so riddled as almost to destroy the value of the plant.

Control. The methods advised for the control of flea beetles may also apply to the tortoise beetle.

Termite Injury

Sweet potato injury from termites or white ants is often serious during dry seasons. The injury from termite may often be confused with that from the sweet potato weevil. Berger (3) emphasizes the distinguishing characteristics of the damage caused by white ants as follows:

1. Absence of larvae (grubs) and pupae in the tunnels when infested by termites, but their presence in apparent abundance when the tuber is infested with the weevil.

2. Absence of frass (excreta) when the injury is due to termites, but an abundance of this in the tunnels produced by the weevil.

3. Exit and entrance holes very apparent with termites, but tuber infested with weevil may show little or no outward evidence of its condition inside.

4. The clean-cut outlines of the tunnels made by the termites are in marked contrast with those made by the weevil (Fig. 20, c).

Besides the differences indicated in the illustrations, several other facts of use in determining the presence of the weevil or termites may be noted:

5. If the plants are growing, tunneling larvae (grubs) in the stems near the ground indicate the weevil.

6. The presence of large (about ¼ in. long) ant-like insects with black heads and snout, brick-red thorax (middle) and legs, and dark steel-blue hind end, is an almost certain sign of the weevil.

7. The presence of whitish rapidly running insects, having much the appearance of ants, indicates termites.

Root Knot

Caused by *Heterodera radicicola* (Greef) Mull.

Root knot of sweet potatoes is commonly found in the Southern States in light sandy soils. It is characterized by small swellings on the lateral feeding roots. This disease, although serious on numerous other crops in the sandy soils, does not seem to injure the sweet potato to any great extent. Root knot is very severe on the cowpea and the okra; hence in small farms, crops which are susceptible to root knot should be avoided, as otherwise the little nematode worms will be greatly increased in the soil.

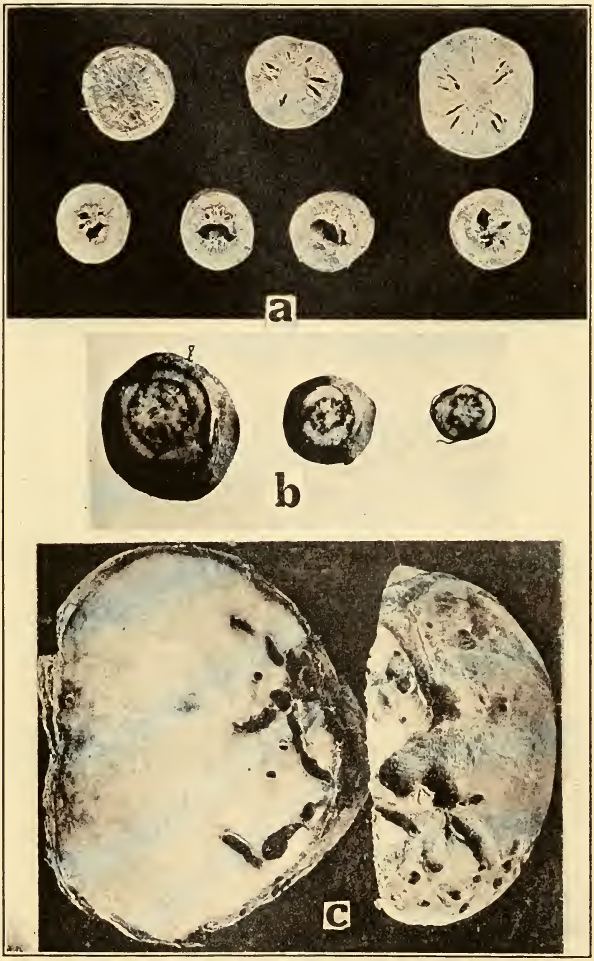

FIG. 20. VARIOUS DISEASES.

a. Hollow heart. *b*. Net necrosis. *c*. Sweet potatoes showing tunnels caused by termite. (*c* after Berger.)

Rat and Mice Injury

These pests are often troublesome in the storage houses. They feed on sweet potatoes by nibbling on them, thereby opening the way to soft rot and many other diseases. The best way to control these rodents is to soak wheat or corn in a solution of one ounce of strychnine sulphate dissolved in one-half pint of water. The grain may be soaked for twenty-four hours and then distributed to various parts of the house where rats and mice may get it. Large quantities of the grain may be soaked in the poison, and then dried and kept for future use. In every case, the poison should be carefully labeled and the poisoned grain protected in such a way that no chickens or any other farm animals may have access to it. In sweet potato houses with floor ventilators the opening to these ventilators should be screened with a ¼-inch galvanized wire cloth so that it will be impossible for rats and mice to enter.

PART III

STORAGE METHODS

CHAPTER XIV

METHODS OF STORING SWEET POTATOES

In the first two parts of this work we have been concerned with methods of producing a good sweet potato crop, free from disease. When this is done, what comes next? Of all the vegetable food products, none is more perishable than the sweet potato. There is very little or no profit derived when the sweet potato is dumped on the market at harvesting, because at that time, the markets are often glutted, and the prices low. The best prices are obtained, and the highest profit attained, when the sweet potatoes are put away in storage during the winter months and sold to the best markets at that time. The final success with sweet potatoes directly depends on how well this crop can be stored.

There are several ways of storing sweet potatoes, namely, dehydration, canning, storing in banks, and storing in drying houses popularly known as "Kiln dryers."

Dehydration

By dehydration is here meant the drying of the sweet potato so as to remove most of its moisture (Fig. 21, a and b compared). The process as far as it applies to sweet potatoes is only in its infancy, and the industry if properly developed may have a great future. With this method, the losses from rot could be wiped out altogether. The principle of dehydration is by no means new; however, present-day methods are decidedly different from early methods, as they are more improved and practical.

Dehydrated sweet potatoes, to command a market, must not have their starch and other substances destroyed by scorching or burning. By proper manipulation, however, the food value, the quality, and the flavor may be conserved well. It should be remembered that sweet potatoes, like any other plants, are made up of cells. These may be compared to extremely thin walled boxes or sacks separated by small interspaces. These boxes or cells are filled with the stored-up food materials. Any method of dehydration must aim to preserve intact the cellular structure of the sweet potato, and permit the equal evaporation of water from the entire inner content. Dehydration, to be successful, must not be so unevenly and rapidly done as to dry and form an outer shell or skin; neither should the temperature be so high as to transform all the cellular contents.

Dehydration on a commercial basis dates from the Boer war. At that time, the British needed large quantities of dried foods for shipment to their troops in South Africa. This product was obtained from Canada where large dehydration plants were established. At the close of the war, the manufacturers had large quantities on hand which remained unused by the British army. This supply was packed in barrels, sealed with paraffin and kept until the recent World War, when it was used again by the British army in France.

In the United States, dehydration until recent years was progressing rather slowly. The investigations of the Bureau of Chemistry, United States Department of Agriculture, have given this industry much impetus through the leadership of Major S. C. Prescott (82).

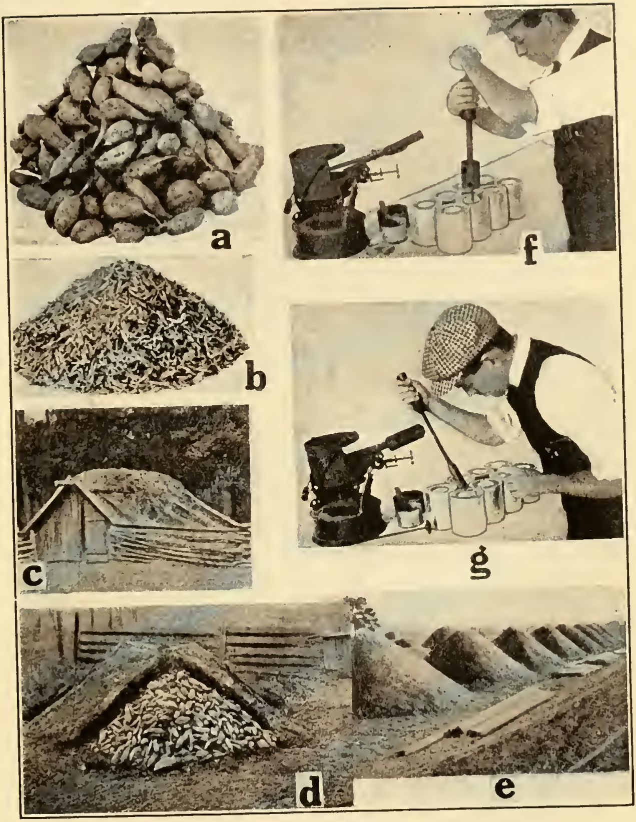

FIG. 21. STORAGE METHODS.

a. One bushel of sweet potatoes before dehydration. *b*. The same after dehydration, showing shrinkage due to loss of water. (*a* and *b* after S. C. Prescott.) *c*. Simple cellar storage house after H. C. Thompson.) *d*. Construction of a sweet potato bank (after R. G. Hill). *e*. Sweet potato banks in the field (after H. C. Thompson). *f*. Capping. *g*. Tipping sweet potato cans. (*f* and *g* after E. T. Miller.)

There are several methods of dehydrating vegetables, which apply equally to the sweet potato.

1. *Tunnel Process.* In this method, a narrow, long tunnel structure is heated by numerous coils or steam pipes horizontally laid. The tunnel is provided with holders, or screened receptacles; these are perforated trays to hold the product to be dehydrated. Through this tunnel is blown a blast of hot air which takes up the air from the moist product. This method is greatly improved by the use of dampers which regulate the flow of air. The objection to this system is that the product may become overheated or scorched, and the food value impaired.

2. *Kiln Process.* This system is used in New York and in California. It was originally adopted for curing hops. This type consists of a chamber with a perforated floor through which heated air rises from a furnace. The material to be dried is spread on the floor and turned several times to obtain uniform dryness. The main drawback in this method is the high cost of operation.

3. *Vacuum Process.* In this method the air is sucked out by vacuum in the same way in which chemicals or liquids are dried. This method is poorly adapted to dehydrate vegetables, because the product loses its food value and quality.

Dehydrated sweet potatoes are prepared in the same way as Irish potatoes; that is, they are cut into flakes or slices with the same kind of machine.

The potatoes are first placed in a washer in which the whole potatoes are thoroughly washed in water with paddles. From the washer, the potatoes are transferred to bins by means of elevated hoppers. From the bins, they are fed into the cooker. The potatoes are then steamed in the cooker, which has a capacity of about 800 pounds and is emptied every half hour. From the cooker, they are transferred into a trough with a ribbon conveyer which pumps them into the hopper above the drying cylinders, at the same time breaking them thoroughly. Inside of the hopper, the potatoes are mashed considerably between the upper parts of the two cylinders.

The cylinder dryers consist of two heavy hollow-cast cylinders each six feet long and three feet in diameter. These have a smooth surface and are heated by steam. The two cylinders, though parallel, work independently of each other. When revolving, each cylinder becomes coated with a layer of cooked potatoes. The thickness of the coat is regulated by small rollers set closely against the surface of the large cylinder. The heat in the hollow cylinder quickly dries the coat of mashed potatoes. By that time, the revolving cylinders are set against knives which scrape off the coating. The product is dry and breakable and looks like thin crepe paper. These are the sweet potato flakes.

Sweet Potato Flour. The flakes as they are dropped into a trough are sucked into a large pipe by means of a strong fan. From the pipe, the flakes are thrown into a collector, whence they slide down to a mill and are pulverized into flour.

Neither dehydrated sweet potatoes nor sweet potato flour have as yet been offered commercially on markets at home or abroad. These two products, however, present new industries with a great future. The process of dehydrating sweet potatoes will solve the storage problem and will reduce all losses from rots. Excepting diseased stock, all grades of sweet potatoes, even the culls, could be utilized for that purpose and there would be no waste. With this method, too, large quantities of dried sweet potatoes could be sold and shipped to many of the European countries. It has been estimated that a bushel of fresh sweet potatoes weighs about 46 pounds, which after dehydration weighs 10 pounds. It is thus seen that we economize 36 pounds in freight by eliminating water only. Dehydrated sweet potatoes may keep indefinitely if properly protected from insect injury. When ready to be cooked they have to be soaked in water, and the same water is used again in cooking.

Canning Sweet Potatoes *

Canning was not known, until 1806, when an Englishman by the name of Laddington first found that food put in closed containers and heated would keep indefinitely. In 1810, Nicholas Appert, a Frenchman was the first to obtain a patent on this process.

Sweet potato canning has of late assumed an important economic aspect in New Jersey, Delaware, Maryland, Virginia, and in many southern states.

Excepting diseased material, canning sweet potatoes affords means of utilizing all grades, even culls, and of reducing all losses from rots. The canned product is palatable, and in most respects as acceptable as freshly cooked, stored sweet potatoes. It will keep almost indefinitely, and may be shipped anywhere in the world.

Blanching. By blanching is here meant the plunging of the sweet potato in boiling water for several minutes. This is done to remove adhering dirt, and eliminate any objectionable taste.

Capping. The steps in this process are as follows:

* See also; Magoon, C. A. and Culpepper, C. W. "A study of sweet potato varieties with special reference to their canning quality." *U. S. Dept. of Agr. Bul.* 1041:1–34, 1922.

The cap is placed over the opening and the soldering fluid or flux (also known as zinc chloride) is applied with a small brush. Then a hot capping steel is held to the solder-rimmed cap until the solder is melted and fills the groove in which the cap fits. The steel is turned around a few times and the rod that runs through the center pressed down. This rod is sufficiently long to allow the capper to be raised from the cap without releasing the pressure on the cap by the rod. The steel should be lifted for an instant to allow the solder to set before removing the center rod from the can (Fig. 21, f and g).

Exhausting. This means the driving out of surplus air from the can. It is easily accomplished by adding a little boiling water to the can before capping.

Tipping. This is soldering the vent hole, to seal the can completely.

Processing. This is the final cooking or sterilizing of the sealed can.

Cooling. As soon as the cans are taken out of the steam cooker, they should be cooled by being dipped in cold water. All cans after processing should be carefully tested for leaks.

Sweet potatoes can be canned successfully under steam pressure only. There are two ways of packing; one where the whole potato is packed dry, the other where the potatoes are first cooked to a pulp and then packed. The varieties best suited for canning are the Yellow Yam, Yellow Jersey, Pumpkin or Dooley Yam, Southern Queen, Big Stem Jersey, Triumph, and Nancy Hall. When No. 3 cans are used, the packed cans are sterilized eighty minutes at 240 degrees F. When No. 10 cans are used the packed cans are sterilized for two and one half hours at 240 degrees F.

Storage in Banks and in Cellars

Storage in Banks. This is perhaps the crudest and oldest method of storing. It is still in vogue to-day in the South, but it is being gradually replaced by properly constructed storage houses.

Construction of Banks. Banks (Fig. 21, d and c) should be located on well-drained land. Stagnant water will ruin the potatoes. It is necessary to make the bottom of the bank level. The size will vary greatly. It is, however, preferable to construct several small banks instead of one or two large ones. Ordinarily the diameter of the bank varies from 6 to 10 feet. It is necessary to dig two small trenches across the floor at right angles to each other. This will provide the necessary means of ventilation. The two trenches are covered with boards or wooden troughs. At the junction where the trenches cross, a loosely nailed 4-by-4-inch box is set in to form a flue up through the potatoes, its height that of the middle height of the bank. It is advisable to have the four sides of the wooden flue perforated with holes to assist further in the ventilation of the bank. The earth floor of the bank is covered with a 4- or 6-inch layer of straw, hay, dry leaves, or pine needles, and the potatoes placed in a conical pile around the flue (Fig. 21, d). The potato pile is then covered with hay and old corn stalks and allowed to remain in this condition as long as the weather is favorable. This will encourage evaporation of the excessive moisture. As soon as it turns colder, the outer cover of straw and corn stalks is overlaid with 5 to 6 inches of soil. The openings of the floor trench of the ventilators, and of the flue are not shut as long as there is no danger of freezing.

The disadvantages in storing in banks are: large loss due to decay; inferior quality of the sound potatoes, due to lack of curing; loss on the market, because banked potatoes rot soon after being moved; inconvenience of getting the potatoes during cold, rainy weather.

Barre (2) claims that in South Carolina sweet potatoes keep just as well in banks as in regular storage houses. This claim, however, is based on one year's experiment with forty-five bushels stored in three banks. As a rule, banked potatoes will keep fairly satisfactorily in favorable seasons. When we consider the results in a period of years, the losses are heavy. With our present knowledge on sweet potato storage houses there is hardly any excuse for storing in banks, especially when the crop is destined to be marketed.

Storage in Cellars. In the South, sweet potatoes are often stored in a cellar-like structure (Fig. 21, c). It is constructed of a line of posts through the center, supporting a ridgepole. Upon this pole and the ground on each side, the ends of the planks are placed. The ends of the enclosure are boarded up, a door being provided in one end. The structure is covered with sod to a thickness of 6 inches. Such a structure is only permissible where sweet potatoes are grown for home use. In this case it is more advantageous than banks. This cellar may also be improved by having two doors, one at each end, and a ventilator in the roof. This will permit more ventilation. A slat floor raised five inches from the ground, upon which the potatoes may be placed, is an additional improvement.

In the North, in some parts of Delaware, underground cellars are built to store seed sweet potatoes over winter. A pit 8×10×8 feet is dug, and the floor as well as the walls up to the ground level are built of concrete. The roof and the entrance to the cellar are built above ground. A fire is maintained in a small stove during curing, as well as later to prevent freezing. Ventilation is obtained through the ventilator in the roof, and through the door in the front. The potatoes are stored, either in hampers, or in small bins, constructed at each side.

CHAPTER XV

PHYSIOLOGICAL CHANGES DURING STORAGE

THE reason so many have failed and given up in despair is that sweet potato storage has not as yet been placed on a scientific basis. Every grower, every buyer, and every storer of sweet potatoes has his own theories, practices, and pet beliefs. There is yet no uniform standard to go by. The whole industry has been a hit-or-miss proposition. Practices which in one year have yielded fair results have proved a total failure another year. For this reason, all modest and intelligent sweet potato growers agree that the older they get and the more they deal with sweet potatoes, the less they know about storing this crop. The same attitude is current among scientific people. Sweet potato storage has proved a treacherous problem. The difficulty in the past has been that investigators who worked on sweet potato storage have neither studied the diseases nor the physiology of the sweet potato in all its aspects, but have busied themselves merely with devising a house. The pathologist on the other hand gave little attention to any other phase except diseases.

The work of Messrs. Hasselbring and Hawkins (53), of Harter (42) and Weimer (110 and 111), which is only a beginning in this direction, will no doubt help to explain many things which until recently have seemed very obscure. It will be difficult to treat the subject of storage without first considering the physiological and chemical changes which take place in the sweet potato from the time it is harvested and stored, until it is ready for shipment.

The greatest loss of sweet potatoes in storage is due to decay caused by microorganisms which invade the tissue. Chemical and physiological changes in the root no doubt play an important rôle in predisposing the host to decay. This in brief brings us to a consideration of the carbohydrate metabolism of the sweet potato in storage.

To determine this, Hasselbring and Hawkins (53) used two varieties, the Big Stem Jersey, representing the sugary type, and the Southern Queen, the starchy type. Fifteen bushels of each were stored. Nine crates of each were subjected for ten days to "sweating" or curing at a temperature of 27 degrees C. (equivalent to about 81 degrees F.). After sweating, the temperature was dropped to the regular storage temperature ranging from 45 to 60 degrees F. The remaining six crates of each were placed in cold storage where the temperature was maintained at 4 degrees C. (38 degrees F.). The data of the seasonal changes of the potatoes stored in the cold storage room and of those kept under ordinary storage conditions are shown in Tables 24 and 25.

From Table 24 it is seen that under normal storage conditions the moisture content of the root remains fairly constant. This does not mean that there is no moisture lost during "sweating," and during the remaining part of the storage season. The loss of moisture is here compensated by the water formed by respiration. The old belief that the sweet potato lost all its necessary moisture during "sweating" is no longer tenable.

TABLE 24

Carbohydrate Transformations in Sweet Potatoes Stored in the Farm Cellar

Variety, Big Stem

Date of Analysis	Water	Starch	Cane Sugar	Reducing Sugar as Glucose	Total Sugar as Glucose	Total Carbo-hydrates as Glucose	Gain or Loss of Starch (as Glucose)[1]	Gain or Loss of Sugar (as Glucose)[1]
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Grams	Grams
Oct. 20	73.50	19.07	1.90	0.90	2.90	24.09	....	....
Nov. 8	72.99	16.94	3.51	1.32	5.02	23.85	−2.36	+2.12
Dec. 6	71.89	16.42	3.94	1.40	5.55	23.79	−0.58	+0.53
Jan. 4	72.06	16.02	4.39	1.28	5.90	23.70	−0.44	+0.35
Feb. 1	72.18	14.11	6.06	1.67	8.04	23.71	−2.12	+2.14

Average Weekly Temperature	
Degrees C.	Week ending
26.7	Oct. 30
21.7	Nov. 6
16.7	Nov. 13
16.7	Nov. 20
15.6	Nov. 27
15.0	Dec. 4
15.0	Dec. 11
18.3	Dec. 18
15.6	Dec. 25
14.4	Jan. 1
12.8	Jan. 8
11.7	Jan. 15
12.8	Jan. 22
16.1	Jan. 28
15.0	Feb. 5
11.7	Feb. 12

Mar. 1	71.97	13.09	6.96	1.44	8.76	23.31	−1.13	+0.72	[2] 12.2	Feb. 19
									16.7	Feb. 26
									14.4	Mar. 4
									[2] 15.0	Mar. 11
Mar. 20	73.02	13.44	6.40	1.10	7.84	22.77	+0.39	−0.92	15.0	Mar. 18
									16.1	Mar. 25
Mar. 26	72.49	14.47	5.61	0.87	6.77	22.85	+1.14	−1.07	16.1	April 1
									18.9	April 8
April 16	72.87	14.20	6.03	0.90	7.24	23.02	−0.30	+0.47	16.7	April 15
									17.8	April 22
									20.6	April 29
									18.9	May 6
June 1	72.45	14.62	5.85	0.87	7.02	23.27	+0.47	−0.22	18.9	May 13
									17.2	May 20
									21.1	May 27
									21.1	June 3
					Variety Southern Queen					
Oct. 23	71.69	22.09	1.19	0.39	1.64	26.18	....	....	26.7	Oct. 30
									21.7	Nov. 6
Nov. 10	68.41	19.87	2.97	0.77	3.89	25.96	−2.47	+2.25	16.7	Nov. 13
									16.7	Nov. 20
Dec. 7	67.69	19.30	3.50	0.72	4.41	25.85	−0.63	+0.52	15.6	Nov. 27
									15.0	Dec. 4
									15.0	Dec. 11
									18.3	Dec. 18
									15.6	Dec. 25
Jan. 11	67.51	19.75	3.53	0.75	4.46	26.41	+0.50	+0.05	14.4	Jan. 1
									12.8	Jan. 8
									11.7	Jan. 15
									12.8	Jan. 22

[1] Per one hundred grams of material.

[2] Record obtained for only one day.

TABLE 24—(*Continued*)

Variety, Southern Queen—(*Continued*)

Date of Analysis	Water	Starch	Cane Sugar	Reducing Sugar as Glucose	Total Sugar as Glucose	Total Carbo-hydrates as Glucose	Gain or Loss of Starch (as Glucose)[1]	Gain or Loss of Sugar (as Glucose)[1]	Average Weekly Temperature	
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Grams*	*Grams*	*Degrees C.*	*Week ending*
Feb. 3	68.02	19.22	3.95	0.60	4.75	26.11	−0.59	+0.29	16.1	Jan. 28
									15.0	Feb. 5
									11.7	Feb. 12
Feb. 28	68.00	18.99	4.05	0.53	4.80	25.90	−0.26	+0.05	[2] 12.2	Feb. 19
									16.7	Feb. 26
									14.4	Mar. 4
									[2] 15.0	Mar. 11
									15.0	Mar. 18
April 8	66.71	20.35	2.93	0.52	3.61	26.22	+1.51	−1.19	16.1	Mar. 25
									16.1	April 1
									18.9	April 8
									16.7	April 15
May 4	69.21	19.78	3.39	0.51	4.07	26.05	−0.63	+0.46	17.8	April 22
									20.6	April 29
									18.9	May 6
									18.9	May 13
June 4	68.15	20.15	2.80	0.55	3.50	25.89	+0.41	−0.57	17.2	May 20
									21.1	May 27
									21.1	June 3

[1] Per one hundred grams of material.   [2] Record obtained for only one day.

It is interesting to note that the percentage of starch shows a sudden decrease immediately after the potatoes were harvested. The subsequent decrease is more gradual, and continues until a minimum is reached in March. From that time on the percentage of starch rises again. In proportion as there is a decrease in the starch, there is a corresponding increase in sugar.

The causes of the changes in the percentage of cane sugar follow that of the total sugar. In the Southern Queen, after the first rise, it decreases continuously. In the Big Stem, the invert sugar shows a distinct maximum.

The data in Table 24 indicate that sweet potatoes rot in storage in proportion as the starch decreases and is changed into sugar. The secret of proper storage would be to determine the best conditions which would favor the increase of sugar to the extent of giving the stored potato its quality, and at the same time prevent it from rotting.

From Table 25 it is seen that three lots of potatoes were used. One of the Big Stem, and another of the Southern Queen were placed in cold storage after they had been cured. The third lot of Big Stem were kept in warm storage until March 27, and at that date transferred to cold storage. The storage experiments were of short duration, because the potatoes kept only six weeks, and then rotted.

The data in Table 25 show that at low temperatures the starch disappears and is replaced by an accumulation of sugar much faster than under warm storage conditions. This would indicate the reason why sweet potatoes rot in cold storage. Harter (51) has shown that under low temperatures, sweet potatoes are rotted by certain organisms which apparently are unable to work

TABLE 25

Carbohydrate Transformations in Sweet Potatoes in Cold Storage

Big Stem, First Lot [1]

Date	Water	Starch	Cane Sugar	Reducing Sugar as Glucose	Total Sugar as Glucose	Total Carbo-hydrates as Glucose	Gain or Loss of Starch (as Glucose)	Gain or Loss of Sugar (as Glucose)	Average Weekly Temperature: Degrees C.	Average Weekly Temperature: Week ending
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Grams	Grams		
									7.8	Oct. 23
Nov. 8	72.99	16.94	3.51	1.32	5.02	23.85	....	....	7.2	Oct. 30
									5.6	Nov. 6
									5.6	Nov. 13
Dec. 9	72.99	13.31	6.46	2.02	8.82	23.62	−4.03	+3.80	4.4	Nov. 20
									4.4	Nov. 27
									4.4	Dec. 4
									3.9	Dec. 11
									3.3	Dec. 18
Dec. 21	70.77	10.80	7.33	1.60	9.31	21.31	−2.79	+0.49	2.8	Dec. 25

Big Stem, Second Lot[1]

Mar. 27	72.19	12.99	6.41	1.65	8.39	22.82	....	....	....	.....
April 30	73.32	9.74	8.74	2.44	11.64	22.47	−0.361	+0.325	....	.....

Southern Queen[2]

Nov. 10	68.41	19.87	2.97	0.77	3.89	25.96	....	....	7.8 7.2 5.6 5.6 4.4 4.4 4.4 3.9 3.3 2.8	Oct. 23 Oct. 30 Nov. 6 Nov. 13 Nov. 20 Nov. 27 Dec. 4 Dec. 11 Dec. 18 Dec. 25
Dec. 8	66.77	17.40	5.93	0.59	6.83	26.16	−2.74	+2.94		
Dec. 22	67.57	16.48	6.94	0.65	7.96	26.28	−1.02	+1.13		

[1] The figures are all calculated for the original water content of the roots, 73.50 per cent.

[2] The figures are all calculated for the original water content of the roots, 71.69 per cent.

under higher temperatures. The current belief of growers is that sweet potatoes freeze at about 40 degrees F. From the above data and the work of Harter (51) it is evident that the sweet potato does not freeze at that temperature, but that the starch is rapidly displaced by cane sugar, and at this stage, the potato becomes susceptible to attacks of various fungi. The temperatures at which sweet potatoes would actually freeze is as yet unknown. This is an important consideration from the carriers' point of view. Sweet potatoes are often damaged in transit, and the shipper attributes such damage to freezing.

A jury may rightly ask the question as to what is a frozen sweet potato. Evidently, in the past, we have had no clear distinction between a rotted and a frozen sweet potato.

From the data presented above, it is very evident that the starch in stored sweet potatoes is first converted to reducing sugar and this is synthesized to cane sugar. Since it is the sugar in the sweet potato that predisposes it to rot, it is necessary from the viewpoint of keeping quality to know at what temperature the greatest change takes place. The experiments by Hasselbring and Hawkins (53) are very enlightening, although their work is based on a very short storage period. They found that at 30 degrees C. (86 degrees F.), the greater part of the cane sugar is formed during the first 10 to 12 days after the roots have been harvested. This is practically true of sweet potatoes kept at 15 degrees C. (59 degrees F.). However, at 5 degrees C. (40 degrees F.) the rate of the transformation of the starch into sugar is slower, but the reaction is continuous. This is why, after six weeks in a cold storage room, there is so much sugar and so little starch found in the roots. This seems to explain why sweet potatoes rot so rapidly under low temperatures. More extended investigations of the effect of temperature on the conversion of starch into sugar under normal storage is very imperative. More definite information along these lines will help to solve the storage problem of sweet potatoes.

It has already been indicated that in stored sweet potatoes the starch disappears, and is replaced by cane and reducing sugars. From the investigations of Hasselbring and Hawkins (53) it appears that the reducing sugars supply the source of respiratory material. The cane sugar, it seems, is relatively stable. Once this is formed, it is not readily utilized in the process of respiration of the sweet potato. During respiration, the reducing sugars are converted into water and carbon dioxide. Temperature seems to influence the amount of respiration.

CHAPTER XVI

THE CURING PERIOD

There are many farmers in the South who still persist in storing sweet potatoes in banks, believing that there are some mysterious ways about curing sweet potatoes in houses which are not wholly within the reach of the average man. Just how this feeling came about is hard to explain. By curing sweet potatoes is meant driving out the excess moisture from the roots as they are brought in from the field, to enable them to keep better and for a longer time than they otherwise would. Sweet potatoes may be kept over winter without curing, but such potatoes will not stand shipment, and are inferior in taste when cooked. For home markets or where the crop has to be shipped to reach its market, it must be put through the curing period. In banks, this process can not possibly be carried out except occasionally under unusually favorable weather. Curing in the storage house may be accomplished by artificial heat and ventilation. The heat creates air currents in the house and aids in drying the potatoes. The methods of heating are considered on page 213.

Temperature

Much guesswork is as yet attached to the required temperature necessary for curing. Experience has taught blindly that heat is necessary for curing sweet potatoes. Every manager, however, has his own pet theories about temperatures. In much of the sweet potato literature a temperature of 90 to 100 degrees F. is recommended. Some writers advocate that the storage house should be closed from ten to fifteen days during the storage period. If this is carried out literally, a large percentage of the crop will soft-rot. Potatoes seldom keep well if they are heated up to 100 degrees F. with all the doors and windows of the house shut. The high temperature and moisture conditions would favor soft rot and black rot. On the other hand, if the potatoes are given all the ventilation possible during curing, it is difficult to maintain the temperature of the house at 90 to 100 degrees F., as the heat will escape. This is especially true under conditions in New Jersey or Delaware.

TABLE 26

Temperature and Moisture Studies at the Delaware House

October, 1914

Date	*First Floor East*				*Second Floor East*				*Third Floor East*			
	Temperature		*Relative Humidity*		*Temperature*		*Relative Humidity*		*Temperature*		*Relative Uumidity*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
26	..	75	75	60	..	74	76	67	..	65	75	53
27	55	60	50	55	66	66	60	45	66	64	62	30
28	58	63	63	60	62	55	63	66	64	65	65	30
29	60	64	65	60	63	66	70	60	64	65	60	35
30	66	62	45	20	65	66	60	40	64	65	55	20
31	60	65	65	40	64	68	65	50	65	70	50	35

TABLE 26—(*Continued*)

November, 1914

Date	*First Floor East*				*Second Floor East*				*Third Floor East*			
	Temperature		*Relative Humidity*		*Temperature*		*Relative Humidity*		*Temperature*		*Relative Humidity*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	66	88	65	60	68	70	70	65	72	65	55	40
2	66	68	70	35	68	70	75	36	70	68	55	55
3	64	66	65	45	65	58	70	50	60	65	60	25
4	68	72	65	50	70	60	75	50	60	68	65	30
5	60	66	60	25	66	68	60	45	68	68	60	5
6	60	65	60	50	66	68	60	55	66	66	55	35
7	58	66	60	55	62	68	60	50	66	64	70	30
8	68	70	65	60	70	73	65	60	70	68	50	35
9	64	64	60	50	66	65	60	55	64	68	60	50
10	58	62	55	50	62	65	50	50	66	62	60	50
11	63	64	55	50	65	66	60	55	68	60	50	45
12	58	63	60	50	62	66	60	55	68	62	60	40
13	64	68	65	50	66	68	65	55	68	62	55	25
14	65	66	60	50	66	68	65	55	68	64	55	40
15	68	70	70	75	70	72	70	75	70	70	65	80
16	72	66	73	60	74	70	75	65	66	74	70	45
17	60	58	50	45	64	62	55	40	62	60	45	20
18	55	54	60	55	60	62	60	50	66	62	55	35
19	58	60	65	65	63	65	65	70	65	64	60	50
20	60	60	67	60	64	65	67	62	65	64	60	37
21	58	54	58	50	62	63	60	55	65	62	45	30
22	58	58	62	60	62	63	62	60	63	60	50	48
23	53	52	62	50	58	60	60	50	62	60	58	30
24	50	54	57	58	56	60	57	52	60	58	53	40
25	55	58	62	60	60	64	60	60	64	56	50	47
26	56	64	65	62	62	66	65	62	68	60	58	35
27	60	64	67	65	63	67	70	62	66	62	58	45
28	56	62	63	65	62	66	70	65	65	62	57	45
29	63	64	67	68	60	60	68	62	65	64	60	55
30	66	68	75	70	64	66	75	70	65	68	62	62

TABLE 26—(*Continued*)

December, 1914

Date	*First Floor East*				*Second Floor East*				*Third Floor East*			
	Temperature		*Relative Humidity*		*Temperature*		*Relative Humidity*		*Temperature*		*Relative Humidity*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	67	68	75	75	70	72	77	75	70	71	65	60
2	67	70	75	80	70	72	75	77	70	72	68	65
3	70	68	75	73	73	74	77	80	72	75	70	65
4	66	68	67	72	70	70	75	70	70	70	67	60
5	70	68	65	65	70	68	65	68	70	70	62	57
6	65	68	60	62	66	68	67	65	66	65	62	63
7	64	66	65	63	66	68	72	70	66	66	65	55
8	65	64	70	72	68	68	70	75	68	70	65	60
9	64	63	72	70	66	66	70	65	68	66	65	70
10	64	65	67	66	66	66	67	65	65	68	65	60
11	62	62	65	70	65	66	67	72	66	68	67	58
12	62	53	58	50	64	63	67	55	61	64	60	50
13	57	60	57	63	60	64	60	65	58	58	63	65
14	62	62	60	58	64	64	62	60	60	62	63	50
15	52	56	40	60	57	60	55	52	50	56	68	65
16	50	56	48	60	55	60	55	55	58	60	58	45
17	50	57	50	65	54	60	55	55	57	62	45	35
18	50	54	55	65	54	58	60	63	56	62	35	32
19	52	56	62	65	56	60	62	60	58	62	40	45
20	56	56	62	60	60	60	65	60	60	58	50	42
21	56	57	65	72	58	60	68	65	58	60	50	55
22	54	56	57	62	57	60	65	55	58	60	50	47
23	53	54	60	50	55	60	60	60	58	60	42	40
24	50	50	45	48	56	58	60	55	58	58	45	48
25	54	53	50	47	58	58	65	52	56	58	53	40
26	48	52	40	45	52	55	60	55	50	54	55	35
27	47	50	45	50	52	56	55	55	52	54	48	40
28	47	52	50	50	52	56	50	57	54	54	42	40
29	52	54	50	50	56	60	60	50	54	56	55	55
30	54	55	55	55	60	60	60	55	58	58	56	62
31	52	52	55	60	58	58	60	60	52	56	50	45

TABLE 26—(*Continued*)

January, 1915

Date	*First Floor East*				*Second Floor East*				*Third Floor East*			
	Temperature		*Relative Humidity*		*Temperature*		*Relative Humidity*		*Temperature*		*Relative Humidity*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	50	52	55	62	56	58	60	65	54	55	45	48
2	50	56	58	50	54	60	67	50	55	56	40	50
3	51	53	55	60	54	58	55	63	52	56	40	35
4	51	53	63	60	55	58	65	50	54	54	33	50
5	50	56	60	57	55	61	63	55	52	60	45	57
6	55	60	60	60	60	65	65	60	56	64	50	55
7	64	64	60	50	66	68	67	65	64	66	62	55
8	58	60	62	55	60	62	67	65	58	60	50	50
9	58	62	62	55	60	64	70	60	58	58	50	50
10	54	56	55	60	58	62	50	63	54	62	52	45
11	52	56	58	60	58	62	50	60	54	58	55	50
12	62	63	60	60	64	66	72	70	62	62	68	70
13	62	66	55	53	64	68	70	65	54	64	70	60
14	60	64	65	58	64	68	70	70	60	65	60	63
15	64	66	67	50	66	70	67	65	62	67	65	60
16	60	64	60	57	64	66	70	65	58	60	60	58
17	63	66	57	60	64	70	65	67				
18	72	75	63	63	74	77	72	57				
19	75	64	65	45	78	68	76	55				
20	64	64	50	57	66	66	57	60				
21	60	62	50	45	62	64	55	55				
22	54	60	45	50	60	64	55	40				
23	58	62	50	55	63	66	57	60				
24	56	56	43	45	60	60	55	55				
25	58	60	65	55	62	64	65	66				
26	56	58	50	58	58	60	65	60				
27	55	58	60	65	58	62	65	67				
28	56	56	65	60	58	60	65	65				
29	51	54	40	60	56	60	53	70				
30	59	52	50	60	56	58	70	70				
31	50	52	60	65	54	58	65	70				

TABLE 26—(*Continued*)

February, 1915

Date	*First Floor East*				*Second Floor East*				*Third Floor East*			
	Temperature		*Relative Humidity*		*Temperature*		*Relative Humidity*		*Temperature*		*Relative Humidity*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	50	58	60	65	54	58	65	70				
2	54	58	65	70	58	66	70	75				
3	56	56	64	67	60	60	72	75				
4	52	50	53	50	56	54	65	62				
5	48	50	50	55	52	54	60	57				
6	47	50	50	67	52	56	55	65				
7	54	56	70	67	58	62	70	70				
8	48	50	56	55	54	54	65	65				
9	45	48	47	50	50	52	60	55				
10	42	48	40	50	47	52	53	55				
11	42	49	55	50	47	55	65	55				
12	49	54	50	55	54	60	55	55				
13	54	53	50	55	57	58	55	65				
14	51	55	63	70	55	62	73	70				
15	56	60	70	72	62	68	70	72				
16	58	56	68	70	62	60	70	75				
17	52	52	60	63	54	56	70	65				
18	44	48	45	55	47	52	60	60				
19	42	48	55	50	58	54	60	55				
20	42	50	50	55	48	56	55	55				
21	48	57	55	60	45	53	55	45				
22	50	58	57	57	46	52	52	50				
23	53	61	57	62	50	58	58	60				
24	60	62	65	68	57	60	57	65				
25	58	59	63	50	56	54	60	56				
26	52	56	40	38	50	52	48	50				
27	48	52	38	35	46	48	43	45				
28	45	48	42	45								

TABLE 26—(*Continued*)

March, 1915

Date	*First Floor*			
	Temperature		*Relative Humidity*	
	A.M.	P.M.	A.M.	P.M.
1	44	46	45	40
2	42	48	42	45
3	48	50	53	45
4	45	48	60	48
5	46	48	54	50
6	50	52	50	55
7	48	48	65	60
8	47	52	65	55
9	44	50	44	47
10	46	53	40	42
11	48	53	38	40
12	48	52	38	38
13	45	52	35	35
14	47	52	35	37
15	47	54	35	38
16	51	55	37	35
17	47	50	31	35
18	47	50	30	35
19	46	52	35	32

In order to determine actual temperature of sweet potatoes in storage, thermometers and hygrometers were installed in Delaware in a large commercial house with a capacity of forty thousand bushels. Similar instruments were installed and studies made in Maryland in a small house with a capacity of eight thousand bushels. The Delaware house consisted of three floors (the system of heating is taken up on p. 213). The Maryland house had two floors and was built of brick.

The results are shown in Table 26. The readings were taken at 7 A. M. and 6 P. M.

In studying Table 26 we see that in a 40,000-bushel, 3-story house in Delaware, the temperature at no time went lower than 50 degrees F. nor above 75 degrees F. during the first forty days. This is especially true during the first fifteen days of the curing. Yet in that house, there were four stoves going full blast day and night. The heat, however, had a chance to escape, because the manager of that house, under the author's directions, provided for ventilation. Table 26 therefore, shows that under the semi-northern climate of Delaware, curing may be effected much more advantageously by a medium temperature, and through an abundance of ventilation. Through this method of curing, the losses from rots at the end of the season were kept down to ten per cent.

From Table 27 it is seen that in the 2-story, 8000-bushel house the temperature during sweating, ranged from 50 to 70 degrees F., the average being 60 degrees. Yet one stove was burning all the time. In this connection abundant ventilation was supplied as long as the outdoor temperature did not go down below 60 degrees. The losses from rot in that house were kept down to 8 per cent.

In the average sweet potato house, without artificial methods of curing, it is far more desirable to cure the potatoes by all the air currents (ventilation) possible, even though at a lower temperature (65 to 70 degrees F.), than overheating the house, and shutting out all ventilation.

TABLE 27

Temperature and Moisture Studies in the Maryland House

October, 1914

Date	First Floor		Top Floor			
	Temperature		Temperature		Moisture	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
28	58	60	58	60	60	20
29	60	64	58	60	60	20
30	62	65	58	60	50	30
31	64	66	62	66	55	10
November, 1914						
1	64	68	62	72	55	15
2	66	70	62	72	55	15
3	66	68	64	64	50	20
4	66	72	64	72	50	30
5	68	66	66	66	50	31
6	64	66	62	66	40	20
7	60	64	58	60	45	20
8	62	68	60	68	55	40
9	60	66	60	68	80	40
10	60	62	58	62	50	10
11	58	60	54	60	50	40
12	58	62	54	64	55	10
13	60	68	60	64	45	30
14	62	64	62	64	50	45
15	64	68	64	66	60	80
16	68	66	68	66	75	60
17	60	60	56	60	60	25
18	58	60	52	60	50	25
19	56	58	54	54	60	65
20	56	60	54	56	70	50
21	54	58	50	54	65	40
22	50	56	50	54	60	55
23	54	60	50	50	60	50
24	52	58	50	52	55	35
25	54	60	50	58	50	45
26	54	60	52	60	65	40
27	56	60	58	58	80	70
28	58	60	56	60	60	58
29	60	60	56	60	70	65
30	60	68	60	68	70	60

TABLE 27—(*Continued*)

December, 1914

Date	*First Floor*		*Top Floor*			
	Temperature		*Temperature*		*Moisture*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	62	62	60	64	80	70
2	60	64	60	64	90	70
3	66	66	66	66	65	70
4	64	64	64	62	65	65
5	60	60	60	60	70	65
6	60	60	58	60	65	70
7	60	58	58	56	70	70
8	58	58	56	56	70	70
9	58	58	56	56	70	70
10	58	58	56	58	75	70
11	56	58	54	56	70	70
12	56	58	52	56	75	65
13	52	56	52	54	65	70
14	54	56	52	54	70	65
15	50	56	48	52	65	50
16	50	54	48	52	70	50
17	48	54	48	54	70	50
18	48	52	48	52	65	55
19	50	52	50	52	65	65
27	48	50	48	50	65	65
28	48	50	48	50	70	65
29	50	52	50	50	65	75
30	54	56	52	58	75	50

TABLE 27—(*Continued*)

January, 1915

Date	First Floor		Top Floor			
	Temperature		Temperature		Moisture	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
3	50	56	50	56	55	50
4	52	56	50	56	70	50
5	52	58	50	60	60	45
6	56	60	54	60	65	55
7	54	60	60	60	75	65
8	54	58	56	58	80	75
9	54	58	52	58	75	60
17	54	60	54	60	80	85
18	60	62	62	62	80	85
19	62	60	62	60	70	60
20	58	56	56	54	65	65
21	54	54	52	52	70	65
22	54	56	54	54	65	60
23	52	58	54	58	65	65
24	54	54	54	54	70	70
25	54	54	54	52	65	70
26	54	56	52	58	65	60
27	54	56	54	56	65	65
28	56	56	54	54	70	60
29	50	54	50	54	65	60
30	50	50	50	54	54	65
31	50	54	52	50	50	50

TABLE 27—(*Continued*)

February, 1915

Date	*First Floor*		*Top Floor*			
	Temperature		*Temperature*		*Moisture*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	52	60	50	54	60	60
2	62	60	52	62	75	60
3	54	54	62	60	60	65
4	52	50	54	54	70	65
5	50	52	52	52	65	65
6	52	58	54	58	70	70
7	52	54	52	54	70	65
8	52	54	50	54	65	65
9	50	54	50	54	65	60
10	52	54	48	58	70	50
11	52	54	48	54	65	50
12	50	54	50	60	50	50
13	50	56	54	56	60	65
14	54	58	54	58	60	60
15	56	60	54	62	75	65
16	60	58	62	58	55	60
17	52	54	52	56	60	60
18	52	58	50	56	55	50
19	52	58	52	58	60	40
20	52	60	52	62	60	40
21	52	58	54	58	60	35
22	52	60	52	60	65	40
23	54	60	54	62	60	40
24	58	58	58	58	70	70
25	54	54	54	52	80	70
26	50	60	50	56	65	40
27	52	56	50	54	65	50
28	52	54	52	56	60	40

TABLE 27—(*Continued*)

March, 1915

Date	*First Floor*		*Top Floor*			
	Temperature		*Temperature*		*Moisture*	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
1	50	58	48	58	60	35
2	52	54	48	52	65	25
3	52	56	52	56	45	20
4	52	60	50	60	45	30
5	52	60	52	52	55	50
6	52	54	52	54	50	50
7	....	....	54	52	50	65
8	....	....	50	54	60	45
9	....	....	48	56	60	25
10	....	....	50	50	65	50
11	....	....	52	54	60	50
12	....	....	50	50	60	60
13	....	....	50	52	65	50
14	....	....	50	54	60	50
15	....	....	48	54	70	50
16	....	....	50	50	70	60

MOISTURE

It has already been stated that in curing sweet potatoes, moisture is given off. Part of this moisture was present in the sweet potato when freshly dug from the ground; the remainder came about from the breaking up of the starch into sugar, carbon dioxide and water.

That moisture is given off during sweating is a well-known fact. However, the amount varies with the variety, and especially with the methods of curing. The work of Price (81) in Alabama shows that about 24.92 per cent of moisture is lost during the entire storage season. This is shown in Table 28.

TABLE 28

Loss in Weight from Moisture Evaporation

Date	*Weight in Pounds*	*Weight Lost*	*Per Cent. of Loss*
1915			
November 10	120		
November 11	118.2	1.8	1.5
November 12	117	3	2.5
November 13	116.1	3.9	3.25
November 15	114.5	5.5	4.58
November 16	113.85	6.15	5.12
November 17	113.25	6.75	5.62
November 18	112.86	7.14	5.95
November 19	112.28	7.72	6.43
November 20	111.95	8.05	6.70
November 22	111.25	8.75	7.29
November 23	110.74	9.26	7.71
November 24	110.53	9.47	7.89
November 25	110.16	9.84	8.2
November 26	109.82	10.18	8.48
November 27	109.45	10.55	8.79
November 29	108.85	11.15	9.29
November 30	108.65	11.35	9.45
December 1	108.40	11.60	9.66
December 2	108.20	11.80	9.83
December 3	108	12	10
December 4	107.70	12.30	10.23
December 6	107.20	12.80	10.66
December 7	107	13	10.83
December 8	106.85	13.15	10.96
December 9	106.40	13.60	11.33
December 10	106.10	13.90	11.5
December 11	105.80	14.20	11.83
December 13	105.55	14.45	12.04
December 14	105.10	14.90	12.41
December 16	104.80	15.20	12.66
December 20	103.80	16.20	13.5
December 21	103.30	16.70	13.91
December 23	103.15	16.85	14.04
December 24	103	17	14.16
December 25	102.85	17.15	14.29
December 27	102.35	17.65	14.7
December 30	102	18	15
1916			
January 1	101	19	15.83
January 14	99	21	17.66
February 1	95	25	19.83
February 14	93.80	26.20	21.83
March 13	90.10	29.90	24.92

The data in Table 28 are not very conclusive, since they are based on only 150 pounds of sweet potatoes, stored in a slatted container. It is doubtful if the same amount of evaporation will occur in large bulks when sweet potatoes are stored in bins. Investigations by the author have shown, that on the average in fairly well constructed sweet potato houses, the loss from water evaporation during the entire storage period varies 6 to 8 per cent in bins, and 6 to 15 per cent in hampers or containers. Similar results are recorded by Manns (63), Mooring (70), and others. One man in Texas with a so-called patent to sell, claims that with his system of curing there is practically no loss from shrinkage (moisture evaporation). Such claims are unreasonable, because sweet potatoes, to keep well, must lose 6 to 10 per cent in weight, but not in bulk.

Moisture is detrimental to the keeping of sweet potatoes. It is found, that in houses where there is the least amount of soft and black rot, the relative humidity does not fluctuate more than 50 to 70 per cent. However, the greatest amount of loss from rots occurs in houses where the relative humidity is near saturation point. It is generally believed that infection can not occur unless there is an actual film of moisture on the surface of the plant or roots. This, however, is not always necessary. Lauritzen (61) has shown that within certain limits of humidity the spore is able to absorb sufficient water to germinate. This is done first by imbibition and later by osmosis. This would seem to explain the reason why it is dangerous to allow the sweet potato house to remain damp. Dampness may be gotten rid of by heat and ventilation.

Methods of Heating Sweet Potato Houses

The manager of a potato house would be greatly misled if he thinks that the last word has been said about heating sweet potato houses. This is something to be worked out for each individual house. While too much heat in poorly ventilated houses is detrimental, some heat is necessary. In the small house it is obtained through a sheet iron, "air tight," wood stove. Coal stoves are also satisfactory although a longer time is reguired to get up heat, which, however, is maintained longer. When wood stoves are used it is advisable to start a fire with dry wood. To maintain it a long time, especially during the night, a few chunks of green wood are put in. In the South, in the unit house of 5000-bushel capacity, the modern school house heating system is recommended. With this system of heating, the stove is raised and placed over an opening in the floor through which air enters from under the house. The air then passes through a jacketed stove where it becomes heated and dried from contact with the stove. By virtue of its being lighter, it rises to the ceiling and spreads to all parts of the house, where it absorbs moisture. It then becomes heavier and settles on the floor, where it is sucked out and escapes through the bottom openings of the flue. By this method, a constant strong circulation of warm dry air is maintained.

In the large sweet potato houses in New Jersey with a storage capacity of 10,000 bushels or more, heat is secured through a hot air heater, or a hot water boiler with pipes around the walls. The heater in this case is located in a cellar, which is utilized for storing canned goods, barrels, or even for storing sweet potatoes.

Medium-sized potato houses, of 25,000-bushel capacity, are heated with good coal stoves. The location of the stoves will depend on the direction of the cold winds. Frequently but one large stove is used, when it is placed near the center of the house. If the cold wind strikes one end of the house it should preferably be placed in that end. Some houses have a small stove at each end. This arrangement is satisfactory in a long house. Still others have a stove in one end with the pipe entering the chimney in the other. In very small houses in the South, heat is maintained through oil stoves. Where natural gas is available, and this is true for many parts of Texas, heat is maintained by gas burners, placed in the aisles of the house or in closed cellars where the heat rises through a slatted bottom floor. For medium-sized sweet potato houses in New Jersey, Delaware, Virginia, and even in all other states of the South, a desirable cellar heating system is recommended by Stuckey (93) of Georgia, which is built as follows: The walls of the cellar from the ground to the floor are made as nearly air-tight as possible. There are four doors from the cellar, one leading from the floor of each bin. With such an arrangement the heat may be turned under one or as many bins as is desired. The flue of the heater extends to the top of the building through the floor of the hallway by means of two elbows. The flue may consist of tiles or ordinary sheet-iron pipes. To furnish sufficient air for the heater, a four-inch tile pipe is put in. This pipe extends from the base of the heater, through the soil, and under the concrete foundation opening on the outside.

A similar arrangement can be made where gas is available. In this case, a pit is dug in the ground where the gas burner is installed. Fresh air is taken in from a large tube which extends outside (Fig. 4, b). As the gas burners are lighted, fresh air is drawn in. The air as it is heated rises, and can be turned in to any bin desired, which is regulated by means of trap doors.

The heating system for the patent houses is arranged somewhat differently. This is taken up on pages 254 to 260.

Thermometers. Money spent for a first-class thermometer is money well invested. Many people claim that they can feel the temperature in the potato house and for this reason dispense with the use of such instruments. This would seem very improbable, and no successful manager of a potato house should be without thermometers.

At least one thermometer should be used for every one thousand bushels of capacity and they should be well distributed through the house. A lower thermometer should be hung on the level with the eyes, and an upper one not higher than the top of the highest bins. The manager should be careful not to depend upon the reading of one thermometer and accept that as revealing the temperature conditions of the whole house, but he should regularly make the rounds of all the thermometers, seeing to it that the temperature gets neither too high nor too low in any part of the house. In case the temperature above is too high and the temperature below is correct, the ceiling vents should be opened at once. In connection with the indoor thermometers it is of course taken for granted that one or two will be hung outside as a guide, and for the purpose of enabling the manager to take advantage of outside weather conditions for ventilation.

Ventilation

It has been previously stated that considerable moisture is given off by sweet potatoes in storage. This is especially true during the curing season. This moisture must not be permitted to remain stagnant in the air. Elliot (21) has estimated that 500 bushels of sweet potatoes give off 350 gallons of water during storage. This must be removed or driven out by whatever means possible. In the average sweet potato house, provided with meagre facilities for ventilation, this cannot be accomplished so readily. In the unit 5000-bushel Texas A. and M. house, ventilation is provided by means of floor ventilators, windows, ceiling ventilators, and cupolas (Fig. 22, a, b, d and e). In the so-called government houses, which are really designed for southern conditions only, the floor and ceiling ventilators, as well as cupola, are not provided for. Instead, one or two small holes are allowed in the aisle which, however, because of their small size, permit but very little floor ventilation. In the large-sized sweet potato houses in New Jersey, the houses are too bulky, and of necessity are built in such a way that the maximum amount of ventilation is not always obtained. Under these conditions, of course, the installation of one or two oscillating electric fans will be of great benefit. In this way the keeping of the sweet potatoes may be considerably improved without necessitating the enormous expense of a so-called patent system. It is sufficiently clear from the foregoing that the object in ventilation is to rid the storage house of its excess moisture.

Hygrometers. In addition to thermometers, it is also desirable to have one or two hygrometers indoors, and one on the outside. The hygrometer is an instrument designed to read the relative humidity, or water vapor in the house. An ordinary Mitthoff hygrometer will answer the purpose. This instrument is inexpensive, and may last two or three years. It gives the direct reading of the relative moisture in the air. In carefully watching the readings of the outdoor and indoor instruments, the condition of the humidity of the air will be known. Based on that knowledge the ventilation of the house is regulated. At no time should the relative humidity of the house be higher than 65 to 70 degrees. On the other hand, when the hygrometer registers a low degree of relative humidity, it means that conditions in the house are right for proper curing and keeping of the sweet potatoes.

Care After Curing

Where sweet potatoes are destined for shipping to the various markets, they must of course be cured. Uncured or "green" sweet potatoes will ship poorly if at all. This is the case with banked potatoes. It is relatively easy to tell when the potato is cured by merely rubbing its skin. When the latter clings firmly to the flesh of the potato it indicates that it has been properly cured. On the other hand if the skin rubs off easily, the potatoes are still green and uncured. Usually growers take the sprouting as an indication of perfect curing. This is generally true but under these conditions it might mean that too much heat had been used during curing. It is not harmful for potatoes to sprout slightly and this usually happens in the average sweet potato house. On the other hand excessively long sprouts indicate that the potato had heat for too long a period.

As soon as the potatoes have been cured, the temperature should gradually be lowered down to fifty degrees F., and maintained there as nearly as possible. However, it may not always be easy to maintain that low temperature, in which case all fires should be put out, and during the day the doors and windows, but not the top ventilator should be closed, in order to keep out the often excessively warm or damp outdoor air. However, doors and windows should be open at night to permit the cool air to come in and closed again in the morning.

The cool air will help to maintain a low temperature during the day. Should it turn cold suddenly it will not, of course, be necessary or safe to open the doors and windows at night, but they may be opened during the day time provided the outside temperature is not below fifty-five degrees. As a safe guide, therefore, whenever the outside temperature is not below fifty-five to sixty degrees, there need be no fear of giving the house all the ventilation possible in order to maintain low temperatures in dry weather. However, in wet weather, after curing, the house should be kept closed, except the top ventilators, and the inside temperatures and relative humidity should be closely watched. As long as the humidity does not run up above seventy degrees and the temperature is maintained at about fifty-five to sixty degrees, little needs to be done. Just as soon as the relative humidity rises, however, a little fire should be maintained in order to drive out the excessive moisture. Under climatic conditions of New Jersey or Delaware, for instance, there will be no difficulty in maintaining a low temperature of forty-five to fifty degrees after curing. In this case the fire is merely lowered and the thermometer closely watched. If the outside air is below 45 degrees F. all the windows should be closed except the ceiling ventilators. Enough fire should be maintained to hold the indoor temperature to about 50 degrees F. If the weather is mild and the outside air about 60 degrees, the house may be given all the ventilation possible and the fires reduced. At night, however, the doors and windows should be closed and if it turns too cold even the ceiling ventilators should be shut, and enough fire maintained to keep the temperature about 50 to 55 degrees F.

Critical Periods During Storage

Most growers agree that the critical period which the sweet potatoes undergo in storage is the time of sweating. This is true since at that time there is given off an excess of moisture from the roots, which accumulates in the house, unless ventilation is good. It is this moisture that is conducive to rots and this condition constitutes the critical period. However, sweet potatoes in storage undergo more than one critical period. It is a mistake to think that the roots sweat but once. There is moisture given off practically every day while in storage, although less in amount than when the potatoes are sweating. Nevertheless, little as it is, if that moisture is not carried away, it will accumulate and cause damage. In poorly constructed and ventilated houses, the sweet potatoes are in a critical period throughout the time of storage. Other critical periods which are the most difficult to bridge over in the South, are the warm, moist, and muggy days of January and February. Here in occasional seasons, the weather suddenly turns very warm and the air humid. During such times, natural ventilation is ineffective, in which case artificial ventilation is resorted to, one or more oscillating fans being used as indicated on p. 216.

Many growers commit the error of shifting their potatoes after they have been put in the bins and cured. This is generally done when an excessive amount of rots is noticed. While this practice may be excused on the ground that it is necessary to save the sound ones by removing the rotted ones, it is not a good policy to move the potatoes after they have been put in the bins, irrespective of the rotting, because such a condition could naturally be traced to a poor house or to poor management. If this policy is continued, the moving of the potatoes from one place to another will result in heavy losses from rot. When considerable soft rot is noticed in the house, the first thing to do is to provide all the ventilation possible. By careful manipulation of the heating and the opening and closing of ventilators, the relative humidity could be brought down to 60 or 70 degrees F. If it is found impossible to remedy the faulty heating, or ventilation, or if the house is too cold, and the heat cannot be maintained, the potatoes had better be sold immediately.

CHAPTER XVII

STORAGE HOUSE CONSIDERATIONS

NEARLY every one who has proper soil conditions, and reasonable climate may produce a crop of sweet potatoes. The largest profits are made when the crop is properly cured and housed over winter in correctly constructed houses (Kiln drying houses). However, many fail to provide the right curing conditions. The low margin of profit from stored sweet potatoes is not always due to low market prices, but rather to losses from rots which are favored by various factors.

The Growing Season. Careful observations and studies have shown that the growing season in the field plays a very important rôle in determining the keeping of the crop in storage. Generally speaking, during warm, moist summer seasons, the growth of sweet potatoes is such as to be conducive to poor keeping. Under these conditions, the roots are watery when harvested; hence the great difficulty in properly curing them later, especially if the weather is wet and warm during the sweating period. On the other hand, long droughts during the growing seasons accompanied by a continued wet spell before harvesting is also detrimental. Under these conditions, the roots grow and develop very slowly at first, more rapid but uneven growth sets in later and this means soft, watery and cracked potatoes, which are hard to cure, and of poor keeping quality. The most favorable season is one in which the rainfall is somewhat below the average, falling regularly at the beginning of the season, and decreasing at harvesting.

Preparing the House for Storage

Some time before harvesting, and in any slack time during the summer, if possible, the house should be carefully overhauled and necessary repairs made. Broken windows should be replaced and careful examination made to see that the doors, ventilators and ceiling and floor vents, fit well, that the roof and floor are tight, and that all rat-holes are closed. Bins which need repair should also receive equal attention. The stove and chimney should be overhauled and cleaned.

In dealing with a house where sweet potatoes have been stored before, it would, of course, be folly, and at least unsanitary, to bring the new crop in without first giving it a thorough cleaning. By utilizing all spare time in the summer, the alert grower will make it a point to give his house a thorough cleaning and remove all rotted potatoes and dust which came in as adhering dirt with the previous crop. These left-over, mummied potatoes and the dust are usually loaded with various germs, which produce diseases in the sweet potato. This refuse should be carefully removed, and all indoor wood work should be disinfected by spraying with a solution of concentrated lime sulphur at the rate of one gallon of the stock solution to nine gallons of water or blue stone dissolved at the rate of five pounds in fifty gallons of water. An ordinary bucket pump, with a long nozzle, may be used to apply the disinfectant. With blue stone (copper sulphate) only wooden vessels should be used, as metal ware will be corroded by the chemical. The copper sulphate may be dissolved more readily by suspending it over night in water in a muslin sack. The advantage of copper sulphate over lime sulphur is its freedom from any disagreeable odor. Both however are poisonous and great care should be taken to prevent any of the farm animals or children from drinking them. No injury whatsoever occurs, when the poison is accidentally applied to the hands or clothing. When lime sulphur is used it also acts as an insecticide, killing any possible insect, or insect eggs which may hide or cling to the wood work. Another reliable method for disinfecting sweet potato houses is the formaldehyde gas method, used as follows: The house is at first made as tight as possible by closing all doors, windows, and ventilators except the exit door. Each one thousand cubic feet of house space will require three pints of forty per cent formaldehyde and twenty-three ounces of potassium permanganate. To carry out this operation it is essential to use a crock of three gallons' capacity for every thousand bushels house space. Where deep vessels are not used the chemical action will be so violent that it will boil over, and the effect of the potassium permanganate will be lost to a certain extent. The formaldehyde and the potassium permanganate should be divided equally into as many portions as there are crocks. The permanganate is placed in the crocks first and the formaldehyde poured on it, after which the operator leaves the house at once, closing the door tightly behind him. The operator should pour the formaldehyde into the crock farthest from the door, first, working backwards toward the exit door. This will obviate inhaling the formaldehyde fumes, which are poisonous. For best results it is necessary to sprinkle water on the floor of the sweet potato house before fumigating with formaldehyde and potassium permanganate. The added moisture in this case will insure a better chemical reaction. It is also necessary for safety that the operation be performed by two persons, so that in case of accident the other will be on hand. Under the present abnormal prices both the formaldehyde and the potassium permanganate are too high to justify their use. Under normal prices, however, this method is very desirable, as it kills the spores of disease-producing organisms as well as rats which may be infesting the house. Moreover, this method is a great labor-saver. Many growers often burn sulphur, believing that this acts as a disinfectant. Investigations, however, have not shown this to be a fact, although burning the sulphur is none the less effective in controlling mites and also in killing rats. In disinfecting with formaldehyde the house should be kept closed for at least forty-eight hours or longer if desired, after which time it should be opened and allowed to air. One of the doors should be opened at first. In six to twelve hours most of the formaldehyde fumes will have escaped, when the remainder of the doors and windows as well as the ventilators should be opened.

After the house has been cleaned and disinfected, and about two days before the crop is to be brought from the field, it is desirable to make a little fire, in order to dry the house and to raise the temperature to 70 degrees F. At this point the house is ready for storing.

Filling the House

It is the customary belief of managers of sweet potato houses that it is necessary to fill the house just as rapidly as possible, fill each bin at a time, and one after the other. The reason given is that the potatoes should be put in the bins so that they may be cured as nearly at the same time as possible. This, however, is not always necessary, and in fact not desirable, especially during damp weather, when the potatoes come in wet or when dug late in the season during rainy weather. In this case, the bins will be filled full at one time, and one after the other, and the sweet potatoes will be given little opportunity to dry on the outside. As a result, they will soft-rot badly. A bin should never be entirely filled at one time. To secure good keeping, the sweet potatoes as they come from the field should be spread out in small quantities in as many bins as possible. This will give them a chance to dry and prevent their going through a heating process. The following plan of filling a potato house will tend to encourage more thorough curing. This applies to storage houses with bins, although a similar system may also be used when potatoes are stored in hampers or crates. Figure 23, a, represents a cross-section through the bins of a storage house. A and B represent the inner back bins; C and D the front bins. When the sweet potatoes are brought in, they are first placed in all the bins marked A, the bins B being left vacant. This gives the potatoes in bins A a good chance to dry and cool down to the temperature of the storage house. When this is done the potatoes are put in all the bins marked B. With this method, all the front bins C and D are still empty and permit the bulks in bins A and B favorable opportunities to dry. When all the inner bins A and B are filled, all the bins marked C are then filled with potatoes, bins D being left vacant to be filled last. This method encourages even drying and prepares all the potatoes for more uniform curing. With this system, a little fire should be kept in the house until the house is entirely full; there-after curing may be started. By following the above method of filling the storage house and taking advantage of all the natural means of ventilation, the curing period may be reduced considerably, and the potatoes cured with a moderate amount of heat. Another precaution which is generally overlooked is that of storing different varieties in the same house. This is unwise, since different varieties require specific handling. The "Gold Skin," for instance, of New Jersey and Delaware is considered a wet potato, containing less starch and more sugar and water. Such a variety, therefore, needs more curing to rid it of its excessive moisture. When stored with a dry potato such as the "Big Leaf," which requires less curing, Gold Skins could not be dried properly in large bulk. Such a variety would keep much better if stored in a separate house. This is of special importance to large commercial houses where various varieties are often handled in the same house. In small houses the curing of varieties separately can not always be done.

Another precaution in filling the storage house is to place all the potatoes from the same field in bins by themselves. In large houses where sweet potatoes are brought in by different growers, all the roots from the same man should be stored together in a separate place. It should be remembered that all the growers do not give their potatoes an equal amount of care. By mixing the roots from various fields and individuals, one takes the risk of spreading disease through the entire bulk.

Storing in Bins Versus Containers

In New Jersey the sweet potatoes in the house are stored in bushel hampers or in crates instead of bins.

This method is satisfactory only in large commercial houses with a capacity of eighty to one hundred thousand baskets. Crates or hampers in this case no doubt facilitate the drying or curing. In small-sized houses with capacities that range from a few hundred bushels to two thousand bushels the storing in crates or hampers is objectionable because, under these conditions, the roots are subject to greater drying and shrinkage. Even in the largest commercial houses, bins could be used to advantage, provided they are divided into small 4′×5′ compartments with the necessary air space between the bins (Fig. 22, c). The tendency in the larger houses in the South is to store altogether in containers. With this method, the cost of bin construction is eliminated entirely. Moreover, after the storage season, the house remains free and unobstructed, and may be utilized for storing Irish potatoes, peanuts, hampers, etc. Many growers store in the same containers which are used for shipping the crop. Since sweet potatoes must be repacked and graded for shipping, the above method is economical as it requires no extra expense of money for storage receptacles. Many growers store in bushel peach baskets, others in hampers, others in bushel boxes or crates especially built for that purpose. When containers are used for storage, a platform consisting of a raised false floor is made to provide the necessary ventilation, just as was done in the case of bins.

CHAPTER XVIII

CONSTRUCTION OF COMMERCIAL CURING HOUSES

Before considering the various types of storage houses used, it will not be out of place to consider their evolutionary development. In the tropics, the sweet potato is practically a perennial. There, the roots are dug a few at a time, and only as needed for eating purposes. In the sub-tropical countries and where frosts are sufficient to kill vegetation, the sweet potato must be harvested. In the first attempt at storing this crop the banking method was employed. As unsatisfactory as this method is, it answered the purpose. However, when sweet potatoes were recognized as a commercial crop and the acreage extended, better storage methods had to be developed. Unfortunately little is known as to how this evolution from storing sweet potatoes in banks to storing in regular storage houses came about.

Mr. W. B. Gordy of Laurel, Delaware, claims that his grandfather was the first to build a sweet potato house in 1849. An ordinary pit was dug under the kitchen stove, deep enough to contain about ten bushels of sweet potatoes. The heat from the stove helped to cure the potatoes. When this was done, they were covered with sand, and used when desired. A few years later Mr. Gordy's grandfather decided to place his potatoes in a small log cabin which was heated by a wood stove. There are other old growers still living, in New Jersey and in Maryland, each of whom claims to have originated the storage house idea.

An undated pamphlet, "Keeping Sweet Potatoes," by J. W. Beeson, President of Meridian College, Meridian, Miss., has this statement: "The Meridian College of Meridian, Mississippi, has been making experiments for many years in order to discover a plan by which sweet potatoes can be kept with reasonable certainty to be marketed when prices are higher. We now have solved this problem." Mr. Beeson further states: "The United States Department of Agriculture at Washington, D. C., sent a man to study our plan, pronounced it a success, and got out a bulletin on the subject but forgot to give the College credit for the invention. We discovered the plan and built the first house ever built." Mr. Beeson's storage house is not different from the small house ordinarily built in the South. Neither is it certain that he "built the first house ever built." It is more likely that the sweet potato storage house idea originated in New Jersey or Delaware, where sweet potatoes naturally need more protection during the winter. From the above two states the storing of sweet potatoes in especially constructed houses has gained in favor wherever this crop is grown in the United States.

Progress in the development and improvement of the sweet potato storage house is based on knowledge of the culture and diseases of the sweet potato. Much is still to be learned about this apparently perplexing crop. The ideal sweet potato house does not exist as yet; neither has the last word been said about it.

Type of House

The sweet potato houses most commonly constructed are frame structures (Fig. 24, c and d). These are relatively inexpensive and easy to build. Houses are frequently built of concrete; these, however, have not as yet proved their worth, since it is difficult to prevent moisture from collecting on the walls. This may, to a large extent, be overcome by lining the inner walls with lumber. Sweet potato storage houses are often also built of bricks (Fig. 24, a and b). To be satisfactory, the walls should be built of a double layer of bricks, with a small dead air space between. Storage houses are now being built of hollow tile.

Foundation. The foundation may be in the form of pillars for raised frame house or of solid walls for houses built with cellars. The raised frame structures, girders 6 by 10, or 8 by 8 inches are placed on the pillars. The foundation itself is often built of stone, cement, or bricks. In any case, it should extend about 20 inches above ground level. Plates 2 to 3 inches thick, and 8 to 10 inches wide are placed on the wall. In New Jersey, Delaware, Maryland, and Virginia, foundation walls are used principally rather than pillars. In this case small windows should be placed in the foundation wall to provide means of intake of outdoor air for the cellar or heating room. Whether pillars or solid outside foundation walls are used, center pillar supports should not be overlooked.

Walls. The principles of building various-sized storage houses are about the same. The walls of the storage house according to Thomson (106), are made by setting 2-by-4-inch studs on the girders every 2 feet and nailing them to the sleepers. On the outside of the studs 1-by-6-inch boards are nailed diagonally to brace the wall; over these a layer of heavy building paper is tacked, and matched siding then put on. A layer of 1-by-6-inch boards is nailed on the inside of the studding, then a layer of building paper, and over this matched boards. In the lower South, the first layer of boards on the inside of the studding may be omitted so far as the control of temperature is concerned, but in regions of high humidity (near the seacoast) it is deemed advisable to use four layers of boards, two on the inside and two on the outside of the frame, as suggested above. The tighter the walls, the less difficulty will be encountered in controlling both temperature and moisture. Two 2-by-4-inch pieces should be placed on top of the studding for "double plates," to which the rafters are nailed. The floor is made by laying 1-by-6-inch sheathing over the joists, then a layer of heavy building paper, and over this 1-by-4-inch tongue-and-groove flooring. The building may be covered with shingles, roofing paper, galvanized iron, or any other kind of roofing material; but galvanized iron is to be preferred, because it is durable and lessens danger from fire, thus reducing the rate of insurance. 2-by-2-inch scantlings are used for rafters, and the roof made tight to keep out the cold. The rafters should be cut to fit over the plate at the lower end and to fit snugly against the ridge pole at the upper end. On the outside of the rafters a layer of 1-by-6-inch sheeting is placed, then a layer of building paper, then another layer of 1-by-6-inch sheeting, and over this the roofing material. On the inside of the rafters a layer of 1-by-6-inch sheeting is nailed, then a layer of heavy building paper, and over this a layer of tongue-and-groove ceiling. If desired, joists may be placed across the building on top of the eave plates, and the sheeting, paper, and tongue-and-groove material nailed to the top side of them instead of to the rafters. These joists, if securely nailed to the plate, will serve for tying the sides of the building together, as well as for carrying the insulated ceiling.

In a large house, this method of ceiling is very satisfactory, as it gives loft space above the storage room and requires less ceiling material.

The sides of the building should be tied together, to prevent spreading. This can be done by nailing 2-by-4-inch pieces to the plates or to the lower ends of the rafters. It would be an advantage to have these pieces over the bin supports.

The space between the walls should be left open, because any material used to keep out the cold will absorb moisture. Many storage houses have been built with sawdust, shavings, or similar material between the walls, but this practice should never be followed. Sawdust will take up moisture and when once wet will dry out with difficulty. This moisture will keep the house damp and cause the walls to rot. The air space is a good insulator if the walls are made tight.

Aisle Space. The average sweet potato house does not have sufficient aisle space. Ordinarily, but one central aisle is allowed, whereas the bins on each side are placed against the walls or a few inches from it. Bins should never be permitted to be placed close to the wall. Sufficient aisle space should be allowed between the bins and the wall (Fig. 22, d and e).

Ventilators. The secret of a good house is its facilities for ventilation. This is made possible through trap door floor ventilators in all the aisles (Fig. 22, d and e). Ventilation can also be added through numerous doors and windows (Fig. 22, a). The bottom of the windows should be within 18 inches or 2 feet of the floor. Both doors and windows must be made to close tightly so as to keep out the cold wind whenever necessary. All windows should be made to open from the inside. This is possible only when sufficient aisle space separates the bins from the walls. In addition, shutters built inside of the windows will help to keep out cold air. The bottom of the floor ventilators should be covered with ¼-inch galvanized wire cloth to keep out rats and mice.

Cupola. The cupola (Figs. 22, a, 25, a and b) solves the roof ventilation. The opening into the cupola is controlled by means of trap doors in the interior of the house ceiling.

Bins. The bins are divided into four quarters (Fig. 22, c) consisting of two lower and two upper. This division into small compartments reduces the bulk of potatoes in each portion, to facilitate the curing. The bins are raised above the floor so as to allow circulation of air from underneath.

Where it is not desired to store in bins, the same house may be utilized for storing in hampers, baskets, or crates. For this purpose slatted platforms, covering the same floor space as the bins, may be built, upon which the containers are placed.

Loading Platform. In connection with the outside of the house, there is a loading platform (Fig. 23, c). This is built to facilitate the unloading of the potatoes from the wagon into the house, or in taking the potatoes from the house for shipment.

CHAPTER XIX

ESTIMATE REQUIREMENTS OF STORAGE HOUSES

THE kind and the capacity of the house would naturally depend on the acreage. No one should undertake to build a large house if he has only a small amount of sweet potatoes to store. Under these conditions it would be difficult to keep the house without wasting fuel or chilling the potatoes. On the other hand it is a mistake to build a small house to take care of a large acreage, as in this case the house will naturally be filled to overflowing and make it impossible to take care of the ventilation which is so essential. Progressive growers, therefore, first of all decide on their acreage and build the size of house accordingly.

On the farm, whether the house is large or small, it should be located not far from the home. In this way it will be possible to give it all the necessary care. The very large commercial house should be located near a railroad switch. This will do away with much unnecessary hauling, which never benefits, but, on the contrary, injures the sweet potatoes.

THE SMALL HOUSE

By a small house is here meant one with a capacity of 500 bushels. The small house in New Jersey, Delaware, Maryland, or Virginia, is usually built two stories high, and the foundation wall built deep in the ground. In the South, the small house consists of but one story, and the floor is raised from the ground on pillars, in order to permit ventilation from underneath.

For the South, the small house recommended is the small "government" house of 500-bushel capacity. It could be decidedly improved by modeling it after the Texas A. and M. house (Fig. 22, a to f).

Bill of Materials for a 500-Bushel House *

DIMENSIONS, 12′ 0″×16′ 0″. CAPACITY, 500 BUSHELS

Quantities are for dimensions shown on drawing and must be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete

Mixture—One (1) part Portland cement, three (3) parts sand, and five (5) parts gravel or broken stone; or one (1) part Portland cement and six (6) parts bank run gravel

Quantities for Concrete—Cement, 6 sacks; sand, 20 cu. ft.; gravel, 31 cu. ft.; or cement, 6 sacks; bank run gravel, 1.5 cu. yds.

Chimney

190 brick

Mixture for Mortar—One (1) part Portland cement, three (3) parts sand

Cement, 1 sack; sand, 4 cu. ft.

1–6″ T. C. thimble

6 linear ft. of 8″×8″ T. C. flue lining

* Furnished by the office of Public Roads, and Rural Engineering, United States Department of Agriculture.

Lumber

Girders
- 2–6″×10″×12′ 0″
- 3–6″×10″×16′ 0″

Joists
- 17–2″×8″×12′ 0″

Studs
- 19–2″×4″×16′ 0″

Plates
- 6–2″×4″×16′ 0″
- 6–2″×4″×12′ 0″

Ties
- 4–2″×4″×12′ 0″

Rafters
- 11–2″×4″×16′ 0″
- 1–1″×6″×18′ 0″ (ridge)

Sheeting
- 2,084 B. M. 1″×6″ (includes 20 per cent waste)

Flooring
- 1,000 B. M. 1″×4″ T. & G. flooring (includes 25 per cent waste)

Drop siding
- 615 B. M. 1″×6″ (includes 20 per cent waste)

Platform
- 3–2″×4″×12′ 0″
- 1–2″×8″×14′ 0″
- 3–2″×8″×12′ 0″
- 1–4″×4″×6′ 0″
- 1–2″×12″×12′ 0″
- 2–1″×10″×14′ 0″

Paper
- 40 squares

Trim
- 4–1⅛″×4½″×18′ 0″ S. 4 S
- 4–1⅛″×4½″×14′ 0″ S. 4 S
- 2–1″×6″×16′ 0″ S. 4 S

2–1″×8″×16′ 0″ S. 4 S
2–1″×8″×12′ 0″ S. 4 S
2–1″×6″×18′ 0″
70 Lin. ft. 1⅛″×2½″ drip moulding

Vent in roof
1–1″×12″×14′ 0″ S. 4 S

Bins
6–2″×4″×16′ 0″
3–2″×4″×12′ 0″
2–2″×2″×16′ 0″
6–1″×2″×16′ 0″
34–1″×4″×12′ 0″
65–1″×4″×14′ 0″

Chimney
1–2″×6″×12′ 0″ (platform)

Roof covering as desired, for 290 square feet

Miscellaneous

2 double hung sash and frames, for 12 lights 9″×12″ glass
1 No. 2 glazed door 3′ 0″×7′ 0″, 6 lights 8″×10″ glass
1 frame for glazed door 3′ 0″×7
3 pair 6″ galv. T hinges
1 pair 2½″×2½″ galv. hinges
1 pair 3½″×3½″ loose pin butts for glazed door
1–2″ cleat
1–2″ window pulley
12 feet of ¼″ rope
4⅜″×3″ bolts with 4″ rings
9⅝″×24″ bolts, nuts, and washers
4 sq. ft. ¼″ mesh wire cloth
2 ¼″×2½″ w. steel straps
4 ¼″×3″ lag screws
4 ft. of galvanized iron flashing, 12″ wide
Fastenings for windows, doors, and shutters as desired

Paint
For three coats outside. 4 gallons
Nails
4 pounds 20d
17 pounds 10d
85 pounds 8d
10 pounds 6d
3 pounds 8d finish

If it is desired to build a house of 2,500 bushels, the same general plans as shown in Fig. 22, a to f, may be used. Here, too, the floor ventilators should be of the trap-door type (Fig. 22, d and e).

Bill of Materials for a 2500-Bushel House

DIMENSIONS 20′ 0″×40′ 0″. CAPACITY, ABOUT 2,500 BUSHELS

Quantities are for dimensions shown on drawings and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete
Mixture—One (1) part Portland cement, three (3) parts sand, and five (5) parts gravel or broken stone; or one (1) part Portland cement and six (6) parts bank-run gravel.
Quantities for Concrete

Constituents	*Walls*	*Piers*		*Constituents*	*Walls*	*Piers*
Cement. Sand. Gravel.	79 sacks 8.7 cu. yds. 14.5 cu. yds.	7 sacks 21 cu. ft. 34 cu. ft.	or	Cement. Bank-run gravel.	79 sacks 19 cu. yds.	7 sacks 1.8 cu. yds.

Chimney

500 bricks
Mixture for mortar. One (1) part Portland Cement, three (3) parts sand
Cement 3 sacks; sand, 10 cu. ft.
1–6″ T. C. thimble
18 lin. ft. 8″×8″ T. C. flue lining

Lumber

Girders
2–6″×10″×16′ 0″
1–6″×10″×8′ 0″
Sills
24–2″×8″×12′ 0″
Studs
26–2″×4″×18′ 0″ (size)
3–2″×4″×18′ 0″ (over windows)
12–2″×4″×18′ 0″ (ends)
1–2″×4″×16′ 0″ (ends)
2–2″×4″×12′ 0″ (ends)
4–2″×4″×10′ 0″ (ends)
1–2″×4″×12′ 0″ (over doors)
Plates
24–2″×4″×10′ 0″ (sides)
12–2″×4″×10′ 0″ (ends)
Rafters
44–2″×6″×14′ 0″
2–1″×6″×12′ 0″ (ridge)
2–1″×6″×10′ 0″
Joists
62–2″×10″×10′ 0″
160 lin. ft. 1″×3″ Bridging
Sheeting (includes 20 per cent waste)
2,568 feet B. M. 1″×6″ (roof)
1,032 feet B. M. 1″×6″ (ceiling)
1,200 feet B. M. 1″×6″ (inside walls)

1,344 feet B. M. 1"×6" (outside walls)
960 feet B. M. 1"×6" (subflooring)
Drop Siding (includes 20 per cent waste)
1,344 feet B. M. 1"×6" Drop siding
Flooring (includes 25 per cent waste)
1,075 feet B. M. 1"×4", T. & G. (ceiling)
1,400 feet B. M. 1"×4", T. & G. (walls)
1,000 feet B. M. 1"×4", T. & G. (floor)
Ventilators in roof
2–1"×12"×14′ 0" S. 4 S
Trim
9–1⅛"×4½"×14′ 0" S. 4 S. (windows and doors)
4–1⅛"×4½"×18′ 0" S. 4 S. (corners)
4–1⅛"×4½"×14′ 0" S. 4 S. (end fascia)
12–1"×8"×10′ 0" S. 4 S. (baseboard)
4–1"×6"×12′ 0" S. 4 S. (ridge)
4–1"×6"×10′ 0" S. 4 S. (ridge)
170 lin. ft. 1⅛"×2½" S. 4 S. (drip molding)
Bins
29–2"×4"×18′ 0" (studs)
10–2"×2"×18′ 0" (nailing strips)
20–1"×6"×12′ 0" (ties at partition)
20–1"×6"×16′ 0" (ties at partition)
32–1"×2"×18′ 0" (cleats for loose boards)
8–2"×6"×10′ 0" (over bins)
18–2"×4"×12′ 0" (under removable floors)
418–1"×4"×16′ 0" (slats for bin sides)
72–1"×4"×16′ 0" (slats for removing floors)
162–1"×4"×16′ 0" (loose slats)
Screens (for cellar windows)
3–¾"×2"×16′ 0" S. 4 S.
Battens (for shutters and doors)
8–1"×6"×10′ 0"
Platforms
5–2"×8"×12′ 0" (sides and floor)
1–2"×8"×14′ 0" (sides)

2–2″×12″×12′ 0″ (carriages)
2–4″×4″×12′ 0″ (posts)
2–2″×4″×12′ 0″ (nailing strip)
3–2″×4″×14′ 0″ (joists)
2–2″×10″×14′ 0″ (treads)

Roof Covering
Covering as desired for area of 1,070 sq. ft.

Building Paper
58 squares

Miscellaneous

6 cellar frames and sash for 3 lights 8″×10″ glass
6 double-hung sash and frames for 12 lights 9″×12″ glass
2 No. 2 glazed doors 3′ 0″×7′ 0″, 6 lights 8″×10″ glass
2 door frames, for glazed doors, 3′ 0″×7′ 0″
8 pair 2½″×2½″ galv. hinges for ventilators and cellar sash
8 pair 6″ galv. T. hinges, for shutters and battened doors
2 pair 3½″×3½″ loose pin butts, for glazed doors
2 2″ window pulleys, in ventilator
2 screw eyes
2 2″ cleats
24 feet ¼″ rope
4–⅜×3″ bolts with 4″ rings for floor ventilators
30 lin. ft. ¼ mesh galv. wire cloth, ventilators and cellar screens
24–⅝×18″ bolts, nuts, and washers for foundations
6 lin. ft. galv. flashing 12″ wide, for chimney
4–¼×2½″ wrought-steel straps, for platform posts
8–¼″×3″ lag screws

Nails
2 pounds 30d
10 pounds 20d

30 pounds 10d
300 pounds 8d
100 pounds 6d
10 pounds 8d finish

Paint

For three coats outside. 8 gal.

Latches for doors, windows, shutters, and cellar windows as selected

The Five-Thousand-Bushel Unit House

The greatest difficulty in storing sweet potatoes is met with in large houses with capacities ranging from 10,000 to 100,000 bushels of sweet potatoes. In such houses, the losses from rots are often very heavy. For the South especially, the 5000-bushel unit house is advocated because in that unit of bulk it is possible to make use of all the natural conditions of ventilation and, with proper management, to reduce the losses from rots to a minimum.

Where storage capacity of 10,000 bushels is desired, two units of 5000 bushels each day may be used. These can either be built separately or the building made twice as long. In the latter case one end wall is saved, which reduces the cost of the building, and the wall separating the two units can be built more cheaply, consisting of a layer of building paper and shiplap on each side of the studding instead of two layers of shiplap. Where the houses cannot be built end to end, they should be altogether separated, a space of not less than twenty feet being left between them. The 5000-bushel unit is 26′×59′ 10″×11′ 4″, the house being considerably longer than wide. This is done in order to take advantage of the maximum amount of ventilation.

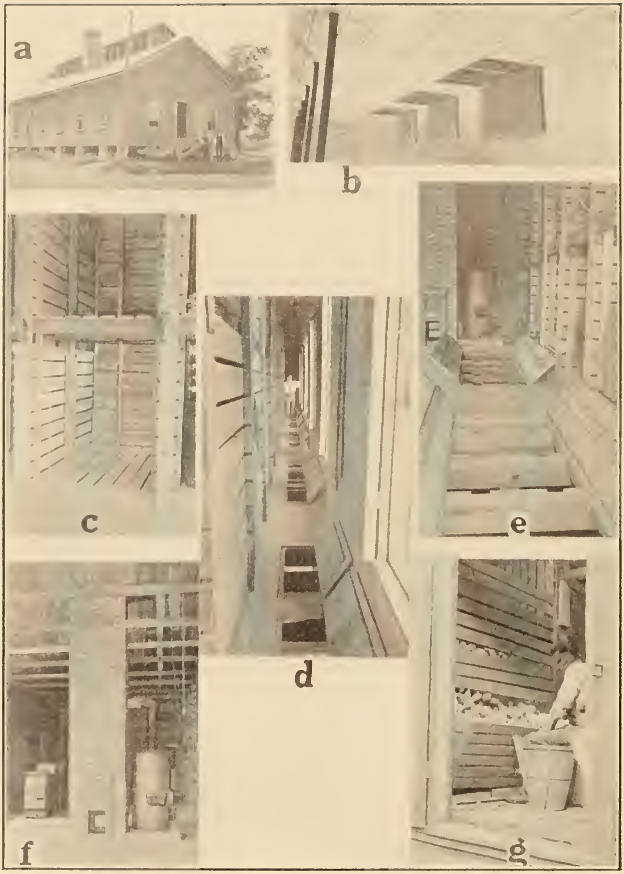

Fig. 22. Unit House.

a. to *g.* Photos showing the Texas A. and M., 5000-bushel-unit house for sweet potato storage. *a.* Exterior view of the house. *b.* Inside view showing ceiling and door vents. *c.* Interior view of upper and lower bins. *d.* Side aisle trap door ventilators. *e.* Middle aisle trap door ventilators. *f.* Stove and flue. *g.* Front gate of lower bin, showing how potatoes are taken out.

The unit house, also known as the Texas A. and M. House, is well suited for Southern conditions. The house is built of lumber for the reason that this is the easiest building material to secure, and the average carpenter can build it. The house is constructed on piers which extend about two feet above ground. This arrangement allows the necessary floor ventilation, which is a distinct feature of this type of house. To protect the house against various severe cold spells, outer drop doors on the north and west sides reaching from the base board to the ground, are desirable. These are raised or lowered as the weather conditions demand. They are, however, merely an extra precaution against cold spells.

The arrangement of floor ventilators, windows, and ceiling ventilators (Fig. 22, a to e) is a distinct feature of the house. Any or all of these may be opened or closed when necessary, thereby creating air currents through any part of the house.

A special and important feature of this house is the method of heating and air circulation, which is accomplished by means of a stove and flue (Fig. 22, f). This is really an adaptation from the modern system of heating school houses (see p. 213). The feature of this system of heating is an opening under the stove through which the outdoor air from under the house enters. The air then passes around a jacketed stove where it becomes heated and dried in contact with the stove. It then rises to the ceiling and spreads to all parts of the house, finally reaching the floor where it escapes through the bottom openings of the flue. By this method a constant, strong circulation of warm dry air can be maintained whenever damp or cold weather makes its appearance.

Bill of Material

Dimensions 26′×59′ 10″×11′ 4″. Capacity 5000 Bushels

HOUSE ONLY

Material	*Size*	*Required*
Piers		
As	Detailed	40
Platform Posts		
As	Detailed	8
Chimney Base		
As	Detailed	1
Sills, Floor		
6″×12″		120 Ft.
9″×12″		180 Ft.
Joists, Floor		
3″×12″	14′ 0″	55
Wall Stops		
2″×4″	22′ 0″	70
Cupola Studs		
2″×4″	16′ 0″	12
Plate Wall		
2″×4″	16′ 0″	24
Plate, Cupola		
2″×4″	10′ 0″	12

Bill of Material—*Continued*

house only—*Continued*

Material	*Size*	*Required*
Joists, Ceiling		
2″×4″	14′ 0″	30
Tires Over H.		
2″×4″	16′ 0″	30
Rafters, H.		
2″×6″	18′ 0″	64
Rafters, Cu.		
2″×4″	16′ 0″	12
Shiplap		
Floor		3,500 Yds.
Ceiling		3,600
Walls, Inside		4,800
Walls, Outside		2,800
Roof		2,400
Building Paper		1,600
Drop Siding	No. 117	2,000
Shiplap	Siding	
1″×10′		1,100
Con. Window Sill		
2″×6″	16′ 0″	12
Shingles		16,000

BILL OF MATERIAL—*Continued*

HOUSE ONLY—*Continued*

Material	*Size*	*Required*
Windows		
4 Light	15″×30″	
1⅜ Check	Rail and Lock	16
Gable Sash		
4 Light	10″×12″	2
Sash Weight		32
Common Brick		4,500
Heater		
Strap Hinges	6″	200
Pulleys	1″	6
Rope		100 Ft.
Paint		2 Coats
Nails		400 Pounds
Bridging		
1″×4″		640 Ft.
Load. Plat.		
4″×10″	20′ 0″	2
2″× 6″	8′ 0″	40
Steps	See Detail	

BILL OF MATERIAL—*Continued*

BIN MATERIAL

Material	*Size*	*Required*
Studding		
2"×6"	16' 0"	52
2"×6"	12' 0"	78
Bin Joists		
2"×6"	16' 0"	96
Slats		
1"×6"	16' 0"	1,100 Pc.
Spacers		
2"×4"	16' 0"	20
1"×2"	16' 0"	50
Shiplap	Stove Aisle	
1"×6"	16' 0"	24
Nails		200 Pounds
Hinges	6"	164

BILL OF MATERIAL—*Continued*

PLATFORM FOR STORAGE OF HAMPERS OR CRATES

Material	*Size*	*Required*
	Post marked *P* on Plans	
2″×6″	12″ 0″	40
Slats		
1″×4″	16′ 0″	200
Platform	Joists	
2″×8″	16′ 0″	25
Nails		
Bridging	1″×4″	400 Ft.

THE MEDIUM-SIZED HOUSE

A 15,000-bushel house may be constructed for the South, as advocated by the United States Department of Agriculture. Here too, however, the small-sized hole vents should be replaced by the trap-door system of floor ventilators as advocated for the Texas A. and M. house (Fig. 22, d and e). A more desirable method would be to construct three 5000-bushel units, built end to end or separated 20 feet from each other. For northern conditions, a 15,000-bushel house may be constructed of three floors, with the Texas A. and M. house as a basis. In this case, the house is built on a solid wall foundation instead of piers. Here one or two revolving fans placed at intervals in the house will help to create better air currents during damp weather. Un-

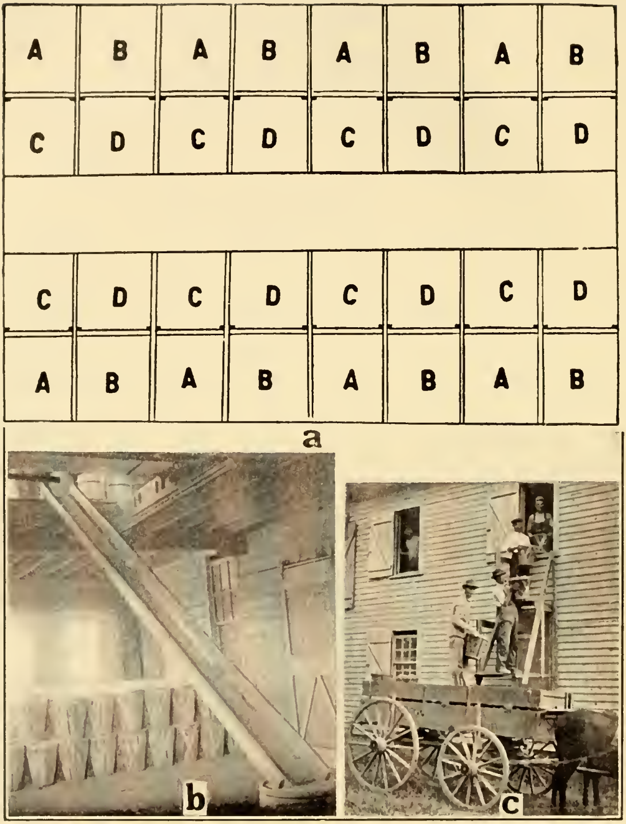

FIG. 23. METHOD OF LOADING AND FILLING THE HOUSE.

a. Diagram showing arrangement of bins for filling. (For explanation, see p. 226.) *b*. Sliding trough connecting two floors and used to lower hampers of sweet potatoes from the upper to the lower floor, preventing unnecessary handling and bruising. *c*. Outside platform conveniently attached to the window and used to load or unload sweet potatoes from two-story houses.

der these conditions, an air pipe should be connected from the outside to the stove. The moist air in contact with the warm stove will become dry before being diffused through the house.

With the large capacity houses, structures of two to three stories (Fig. 25, a and b) possess considerable advantage. There is an economy in space, in material, and in fuel. They are, however, more difficult to handle and to keep dry.

The mistake is frequently made of building several sweet potato houses together (Fig. 26, b). With such an arrangement it is difficult to rid the houses of the inside moisture. There are very few of the really large commercial houses, especially those of 20,000 to 100-000-bushel capacity, that are giving satisfaction. The reason may be attributed to the difficulty in keeping them dry. Those who contemplate building large houses should adopt the Texas A. and M. house plans (Fig. 22, a to g). In the South, the house is raised on piers, and in the colder states, built on solid wall foundations with bottom windows for ventilation.

Bill of Material *

DIMENSIONS 40′–0″×100. CAPACITY ABOUT 15,500 BUSHELS

Quantities are for dimensions shown on drawings and should be altered if dimensions are changed. Footings should be carried down below frost line or to solid ground.

* Prepared by the office of Public Roads and Rural Engineering. U. S. Dept. of Agriculture.

Concrete

Mixture—One part (1) Portland cement, three (3) parts sand, and five (5) parts gravel or broken stone; or one (1) part Portland cement and six (6) parts bank-run gravel.

Quantities for concrete.

	Walls	*Piers*
Cement	185 sacks	34 sacks
Sand	21.0 cu. yds.	4.0 cu. yds.
Gravel	34.5 cu. yds.	6.5 cu. yds.

or

	Walls	*Piers*
Cement	185 sacks	34 sacks
Bank-run gravel	44.0 cu. yds.	8.0 cu. yds.

Chimney

1,700 bricks
Mixture for mortar—One (1) part Portland cement, three (3) parts sand
Cement, 10 sacks; sand, 2 cu. yds.
36 lin. ft. 8″×8″ T. C. flue lining
6–6″ T. C. thimbles

Lumber

Girders
6–6″×10″×10′
14–6″×10″×16′
1–6″×10″×14′
Sills
35–2″×8″×16′
Studs
62–2″×6″×18′ (sides)

9–2″×6″×18′ (over windows)
22–2″×6″×18′ (ends)
20–2″×6″×10′ (ends)
2–2″×6″×12′ (over doors)

Plates
52–2″×6″×12′ (sides)
16–2″×6″×10′ (ends)

Bin Posts under Purlins
36–2″×4″×16′
24–2″×4″×14′

Purlins
24–2″×6″×12′ 0″
12–2″×6″×10′ 0″

Braces under Purlins
12–2″×6″×14′

Rafters
130–2″×6″×12′
130–2″×6″×14′
12–1″×6″×10′ (ridge)

Joists
202–2″×10″×12′
101–2″×10″×18′
800 lin. ft. 1″×3″ (bridging)

Sheeting (includes 20 per cent waste)
11,870 feet B. M. 1″×6″ (roof)
5,280 feet B. M. 1″×6″ (ceiling)
2,920 feet B. M. 1″×6″ (inside walls)
3,450 feet B. M. 1″×6″ (outside walls)
4,800 feet B. M. 1″×6″ (subfloor)

Drop siding (includes 20 per cent waste)
3,400 feet B. M. 1″×6″ (siding)

Flooring (includes 25 per cent waste)
5,500 feet B. M. 1″×4″, T. & G. (ceiling)
3,440 feet B. M. 1″×4″, T. & G. (walls)
5,000 feet B. M. 1″×4″, T. & G. (floor)

Trim
22–1⅛″×4½″×14′ S. 4 S. (windows and doors)
5–1⅛″×4½″×18′ S. 4 S. (corners)
8–1⅛″×4½″×12′ S. 4 S. (end facia)
24–1″×8″×12′ S. 4 S. (base boards)
18–1″×6″×12′ S. 4 S. (roof ridge)
350 lin. ft. 1⅛″×2½″ S. 4 S. drip molding

Ventilators in roof
6–1″×12″×14″ S. 4 S.

Dividing partitions
8–2″×4″×10′ (plates)
8–2″×4″×18′ (studs)
8–2″×4″×16′ (studs)
12–2″×4″×14′ (studs)
8–2″×4″×12′ (studs)
8–2″×4″×10′ (studs)
2–2″×4″×12′ (over doors)
2,655 feet B. M. 1″×4″ T. & G.
Flooring (includes 25 per cent waste)

Screens at cellar windows
9–¾″×2″×16′ S. 4 S.

Bins
72–2″×4″×18′ (studs)
21–2″×2″×18′ (nailing strips)
Ties at partitions
21–1″×6″×18′
42–1″×6″×12′
21–1″×6″×16′
42–1″×6″×10′
} (Stagger joints, using 12's with 18's and 16's with 10's)
118–1″×2″×18′ (cleats for loose boards)
42–2″×6″×12′ (over bins)
21–2″×6″×10′ (over bins)
77–2″×4″×12′ (removable floors)
2,166–1″×4″×10′ (slats for bin sides)
114–1″×4″×12′ (slats for bin sides)
66–1″×4″×12′ (slats for removable floors)

462–1″×4″×10′ (slats for removable floors)
1,083–1″×4″×10′ (loose slats)

Battens for shutters and outside doors
22–1″×6″×10′

Platform
8–2″×4″×10′ (nailing strips)
3–2″×12″×14′ (carriages)
4–4″×4″×12′ (posts)
1–2″×8″×14′ (sides and flooring)
28–2″×8″×10′ (sides and flooring)
10–2″×4″×14′ (joists)
3–2″×10″×14′ (treads)

Building paper
230 squares
Roof Covering
Covering as desired for area of 4,950 sq. ft.

Miscellaneous

18 cellar frames and sash, for 3 lights 8″×10″ glass
18 double hung sash and frames for 12 lights 9″×12″ glass
4 glazed doors No. 2, 3′×7′, 6 lights 8″×10″ glass
4 frames for glazed doors, 3′×7′×6″ studs
4 frames for doors 3′×7′×4″studs
24 pr. 2½″×2½″ glav. hinges for ventilators and cellar windows
26 pr. 6″ galv. T. hinges for shutters and battened doors
4 pr. 3½″×3½″ loose-pin butts for glazed doors
6–2″ window pulleys in ventilator
6 screw eyes in ventilators
6-2″ cleats
100 lin. ft. ¼″ rope
24–⅜″×3″ bolts, with 4″ rings for floor ventilators
110 sq. ft. ¼″ mesh galv. wire cloth, for vents and cellar screens
50–⅝″×18″ bolts, nuts, and washers for foundation

40 lin. ft. galv. flashing 12" wide, around chimney
8–¼"×2½" wrt. steel straps for platform posts
16–¼"×3" lag screws
Latches for doors, windows, shutters, and cellar windows to be as desired
Nails
- 12 lbs. 30d
- 25 lbs. 20d
- 77 lbs. 10d
- 930 lbs. 8d
- 190 lbs. 6d
- 30 lbs. 8d finish

Paint
- For three coats outside. 20 Gal.

Large Houses

The larger houses include the commercial type with an average capacity of 30,000 to 100,000 bushels. Such houses are located mainly around Swedesborough, New Jersey, and a few in Delaware and Virginia. In these large houses the problem in successful storage is a difficult one. This is mainly due to the lack there of proper means of ventilation. Here too, however, the difficulty might be overcome to a certain extent if the heating and ventilation are arranged in a fashion somewhat similar to that advocated for the Texas A. & M. house. Furthermore, some system of artificial ventilation may be necessary, especially during the damp warm weather. This could be provided by installing one or more oscillating fans to suit the particular condition and needs of the house.

Patent Houses

The so-called patent systems aim at curing sweet potatoes through artificial fanning. In the large-capacity

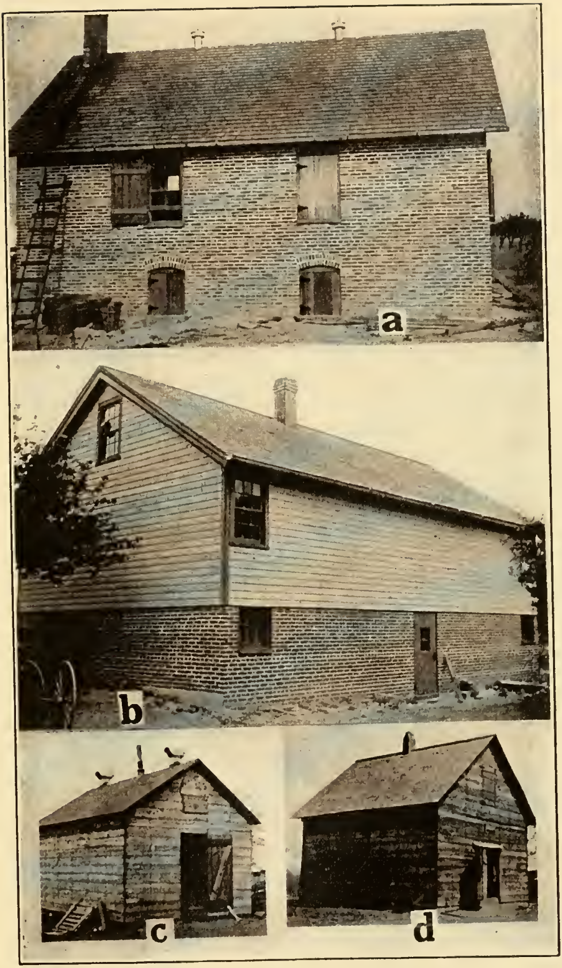

FIG. 24. BRICK HOUSES.

a. 15,000-bushel sweet potato brick house. *b*. Same capacity as *a*, but lower floor built in brick, upper in lumber. *c*. and *d*. Two types of small 1000-bushel sweet potato houses lacking proper roof and side ventilation.

houses, the losses from rot are often considerable. This is brought about by the difficulty of supplying the necessary ventilation fast enough to remove the excess of accumulated indoor moisture. In this case, artificial ventilation secured by means of fans may be very desirable. Simple as this may appear, curing sweet potatoes by means of artificial ventilation has not even passed through the experimental stage. While there are many artificial systems of curing sweet potatoes, none are as yet based on carefully worked-out scientific principles. Each new system derives its birth from some modification of other systems. This striving is bound to promote the industry, yet the unsuspecting public should beware of unscrupulous patentees who are in the business to bleed the industry white. It is not intended here to reflect unfavorably on the honest inventor. Yet we must still beware of those patentees who claim, for instance, that they can cure, in twenty-four hours, sweet potatoes with any kind of disease on them. Science has proved that this cannot as yet be done. Black rot, for instance, is the most persistent disease, and no amount of artificial fanning with ordinary warm air will eradicate it. On the other hand every honest attempt at furthering the sweet potato industry should receive the support of the public, and state and federal institutions.

At present there are several known patent systems of curing sweet potatoes. It is difficult to see how a patent on a fan to send air into a potato house can have much value, and it is still more difficult to see the right to charge an exorbitant price for it. Almost any one with a mechanical bent of mind could install some form of fanning device. However, it would be safe not to invest in any elaborate scheme of artificial curing unless it is first carefully worked out and proved to be scientifically sound. Moreover, the cost of construction, the cost of operation, and the overhead running expenses should be carefully considered.

Types of Patent Houses

There are four types or systems of artificial curing. These are located principally in Arkansas and in Texas.

The Bradley System

With this system, the potatoes are cured by means of a series of short 3×3 ft. fans, mounted on a line shaft elevated about 10 feet high, and extending through the entire length of the building. There are usually two lines of shafts, one in each aisle. One end of the shaft projects to a bearing mounted upon a post a few feet from the wall, to which shaft a band-driven wheel is attached to a thirty-horse-power gasoline engine. The heat necessary for curing is furnished by wood-burning stoves placed at various intervals in the aisles.

The building is 180 by 24 feet and holds 16,000 bushels. The wall is 18 inches thick, double, with a dead air space between, and 14 feet high. The sills rest on a brick foundation which extends entirely around the full length and width of the building. The studdings are of 2-by-6-inch scantling, 14 feet high, ceiled on the inside, weather-boarded and filled with sawdust. The overhead joists or ties are of the same dimensions as the studding, and are ceiled on the top only. The roof is supported by rafters 2-by-6-inches by 14 feet, and covered by sheeting and shingles. The doors and windows are of the same material and thickness as the walls, constructed with beveled edges, making the house quite tight when closed.

The inside of the building (Fig. 27, a) is divided into nine compartments or rooms, each 20 feet wide. Each room is divided into six slatted bins, three on each side, separated by a 6-foot central aisle. Each bin is divided into an upper and lower compartment, each holding 150 bushels of sweet potatoes.

In filling the house, the operator fills one compartment at a time. The fire in the stove in this partition is started, and the temperature during curing is maintained at about 85 to 90 degrees F. To maintain a good circulation in this partition, the vents are opened wide, and fans started. In order to confine the dry and warm air, a heavy canvas or blanket is placed between the first and second partitions. The canvas reaches from the ceiling to the floor, and extends from one side of the building to the other.

To cure, partition No. 2 is filled and operated in the same way as partition No. 1, and the canvas moved forward to separate it from partition No. 3. This method is continued until the house has been entirely filled. Curing is claimed to be effected about ten days after the last partition has been filled. The fires in the stoves are slackened, and the temperature is not permitted to fall below 45 or to rise above 65 degrees F. All the vents, flues, windows and doors are kept wide open during moderately warm weather, but closed during damp cold days. The shrinkage from curing is estimated at 10 to 15 per cent. The Bradley system has been modified by sweet potato specialists in Arkansas. The fans are placed on a shaft running lengthwise in the middle alley, above the compartments, and this rotated by motor power (Fig. 27, b).

The Delaware System

This system was devised by the Dr. T. F. Manus and the author in 1910. It was installed in one of the commercial storage houses in Seaford, Delaware, as a result of investigations carried out by the Delaware Experiment Station, and the United States Department of Agriculture. It consists of a suction fan placed near the ceiling and connected with pipes which are variously distributed. An exhaust pipe permits the exit of the foul air. The fresh air is brought in through the windows in the buildings, and this air is heated inside by means of coal or wood stoves in the house.

A modification of this system is described by Wicks (113). It consists of a blower (instead of suction fan) placed near the ceiling, which forces the air through the bins by means of pipes.

The Wells System

With this system, the warm air is supplied by a motor-driven fan (Fig. 27, g) placed in a room adjoining the storage house (Fig. 27, d). The air pipes or flues are placed on the ground underneath and extend up through the center of each bin, to a point one-half the height of the bin (Fig. 27, e). One stove is placed in the engine room, but none in the storage house. During cold weather, the house is heated by small open charcoal stoves, which are variously distributed.

The Nordin System

The following is a description of this system by Nordin (74) himself. "I use common blacksmith's blower

Fig. 25. Commercial Houses.

a. and *b.* Two and three-storied 30,000-bushel sweet potato houses having proper roof and side ventilators.

No. 1 for a 20'×20' house and No. 2 or 3 for the 20'×40' house. I put them as near to the ceiling as I can and put my line shaft in a small opening over one of the doors. The opening may be made from 1×4 inch lumber which will make an opening 30 inches square, inside measurements. The engine must be on the outside; by not using an air-cooled engine the boiling water from the engine tank will cause a dampness to rise which will damage the potatoes.

"Estimate the speed of engine so as to run No. 1 from 3800 revolutions per minute; No. 2, 2500; and No. 3, 3200. For conveying the air throughout the building, I use what tinners do for "down sprouting" or 4 or 5-inch piping. This is good unless the air loses out at the joints or elbows. With the exception of this objection, it is by far the best, for it is easily handled and can be turned about in any direction desired. After equipping my house in this way, after a day's digging I can throw the air right in under the bins and keep the air circulating. This dries the dampness out and causes all cut potatoes to seal over so that they will keep better than when left alone, for they will sure rot if this system is not used, and the bad part of cut and bruised potatoes is that they rot lots of others."

The Winfield System

A modification of the Nordin system is that in use at Winfield, Texas. Instead of one blower, several are used, one under each bin. All the blowers (bellows) are connected to a revolving shaft which is further attached to a belt-moving wheel in the engine room (Fig. 28, d). Each bellow terminates in an open slatted pipe extending to the center of the bin (Fig. 28, e). The engine is kept outside of the storage house, and heat is supplied by fire stoves which are distributed in the aisles of the house. The house is 160 by 40 feet, and 10 feet high with a capacity of 30,000 bushels (Fig. 28, b and c). A modification of the Wells system is that known as the Hugh Lane. Here the air goes through a furnace (Fig. 27, f) and instead of coming out through a terminating pipe in the bin is forced by a fan and let loose under the floor, so that the air seeps through small openings in the boards immediately under the bins.

The Woods System

Another system for which a patent is apparently pending is that known as the Woods Improved Air Blast System (Fig. 28, a). Here the bin is built the length of the house and a perforated or slatted tunnel constructed in the middle. As the potatoes are put into the bin, the tunnel remains empty, and through this the air is blown in by a blast system.

Having in mind that in artificial curing of sweet potatoes all that is necessary is a fan and moderately dry, warm air, almost any conceivable system could be worked out that will accomplish this purpose. For any system to deserve the consideration of the practical grower it must, of course, be based on scientific principles and actually "deliver the goods" irrespective of weather conditions or the way in which potatoes enter the storage house. Its cost of installation and operating expenses must be such that the overhead expenses will not eat up the profits.

FIG. 26. FRAME STRUCTURES.

a. Two-story 15,000-bushel sweet potato house having proper side ventilators but lacking in roof vents. *b*. Three 15,000-bushel potato houses built together. *c*. Two-story 10,000-bushel sweet potato house lacking both roof and side-ventilators.

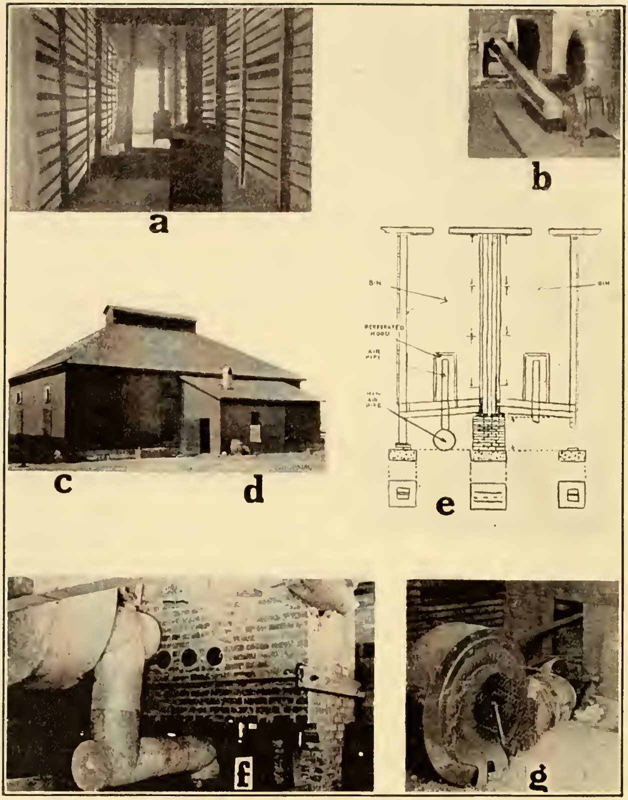

FIG. 27. PATENT HOUSES.

a. Bradley, or overhead mechanical ventilation system. *b*. Blower driven by an electrical motor and used in the Bradley house. (*a* and *b* after Wicks.) *c*. and *d*. Well's sweet potato house showing at *c* the main house and *d*, the engine room. *e*. Drawing of a longitudinal section of a bin in a Well's storage house showing foundation, main air pipe, perforated hood and bin proper. *f*. System in which fan blows air through hot furnace before reaching potato house, thus supplying hot instead of cold air. *g*. Showing fan driven by motor.

Improvement of Faulty Potato Houses

In a sweet potato house in which year after year sweet potatoes are lost from either soft rot or black rot, some steps must be taken to prevent this great waste. Before doing this one must determine where the source of trouble lies. It is essential, of course, to make certain that the losses are not due to mismanagement. The so-called manager who knows very little about sweet potatoes and understands still less about the management, will, in the majority of cases, be responsible for the losses of the crop. In this case, it is very easy to blame the potato house, which cannot defend itself.

Granting that the manager understands his business, the next inquiry must center on the house. From the previous discussion, it is clear that in houses in which heavy losses of sweet potatoes result from soft rot, there is invariably a lack of the necessary ventilation (Fig. 24, b, c and d). This condition will often be met with in a large-sized house which has little or no ceiling (Fig. 26, a and c), wall, or floor ventilation. Here then, all that will be necessary is to remedy that condition. Before making any alterations and improvements it should be carefully decided whether or not the alterations will justify the expense. Very often a potato house may be so poorly constructed that its alterations will cost more than building a new one. In this case, of course, a carpenter should be consulted. Where it is desired to improve the ventilation of the house, it would be well to adopt the ventilation system as advocated for the Texas A. and M. house (Fig. 22, a to f).

Frequently many sweet potatoes rot in a potato house that is loosely constructed. In such a case, potatoes are subjected to chilling during cold weather, and more attention in that direction will often remove the source of trouble. Very often, the heating system is faulty, in which case the heaters either produce an excessive heat which makes it very difficult to rapidly lower the temperature, or it may be that not sufficient heat is furnished at the desired time, in which case, the potatoes become chilled and consequently rot. No one method of heating could apply to all houses. In this case, the manager of the house with a questionable heating system should consult his local tinsmith, or, if possible, some expert who understands his business well.

In houses where many sweet potatoes are lost from black rot, and very little from soft rot, it would seem to indicate that the potatoes receive too much heat. In this case, the house is possibly provided with more heaters than necessary or a high temperature is maintained during too long an interval. The manager, by using a little judgment, will be able to detect the cause of these difficulties and will try to avoid them.

Management. We are not mistaken in our belief that a fool-proof house can never be devised. With poor management, potatoes may be ruined in the best of houses. On the other hand, good results will often be obtained in poor houses where common sense has been resorted to. Having a good house, and a well worked-out heating system, we should next give attention to the careful management of that house. The following directions may serve as a guide:

During curing, the house should be closed, except the flue ventilators and the ceiling ventilators. This, of course, holds true only in cases where the weather is damp or the outside temperature is below 60 degrees F. At that time a constant fire should be maintained and the temperature watched so that it does not go below 60

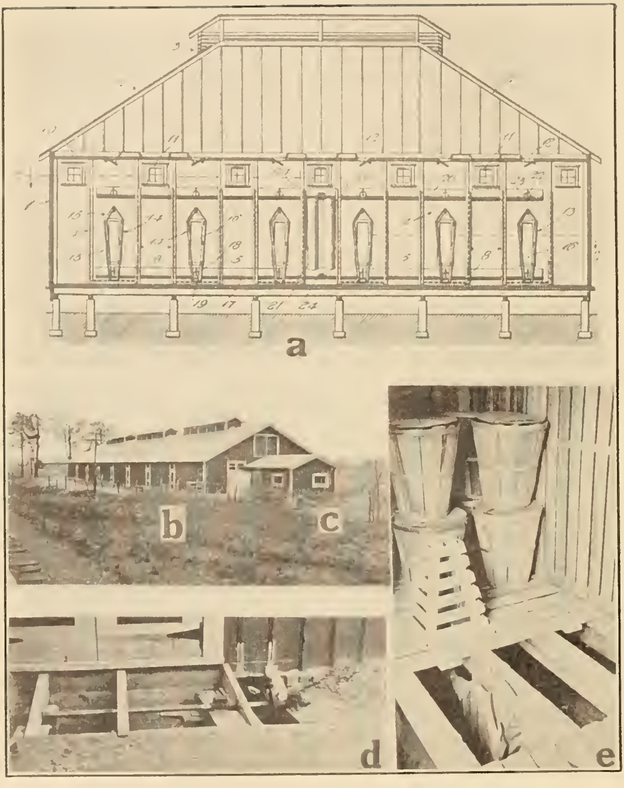

Fig. 28. Patent Houses.

a. Drawing showing system of the Woods sweet potato house (*a*, courtesy of the inventor, Mr. E. M. Woods). *b* and *c*. Sweet potato house ventilated by means of bellows which are run by a gasoline motor, showing at *b* the storage house; at *c*. the engine room. *d*. Shaft which connects the motor and the bellows. *e*. Inner view of bin in *b*, showing the bellows and termination of air pipe in the bin.

degrees or above 75 to 80 degrees F. In case the weather is dry and warm and the outside temperature ranges from 60 to 80 degrees F., a big fire in the stove is not necessary. Instead, all windows, ventilators, and doors should be wide open, and the curing allowed to take place through the aid of the natural air currents. The thing to remember during curing is not to permit sudden fluctuations of temperature. That is, it should not be permitted to fall below 60 degrees or rise above 80 degrees for any length of time. In this direction one should rely closely on the thermometers and hygrometers and guide himself accordingly. After the curing period, the house should be maintained at about 55 degrees F. and never be permitted to go below 40 degrees or above 60 degrees. During cool and dry weather, with the outside temperature registering 55 to 60 degrees F., no fear should be entertained as to giving the house all the ventilation possible. However, if the weather is rainy and the air damp and cold, everything should be closed except the flue and ceiling ventilators, and a small fire maintained so as to prevent the potatoes from freezing. During very cold weather, when it is difficult to maintain a temperature of 50 to 55 degrees F., the house should be closed altogether and enough fire maintained to keep up the above temperature. Should the house at any time become wet and saturated with moisture (this will be indicated by the reading of the hygrometer), a fire should be maintained with enough ventilators open to keep down the temperaure to about 50 to 55 degrees F., and the relative humidity of the air about 60 to 70 per cent.

CHAPTER XX

MARKETING

Marketing usually begins with digging and continues all through the season into the winter months. The greatest profits are of course made when potatoes reach the market during the winter months. There are two methods employed in the large growing districts for selling and distributing the products. One is to market direct from the field and the other to store for winter demands. Good profits are generally made when sweet potatoes are marketed very early; however, little is to be expected when the crop is dumped on the glutted market during digging time. In marketing direct from the field, it is usually customary to dig, sort, pack, and market all in the same day. Here the potatoes are graded into primes, seconds, and culls, the latter being fed to stock. The first two grades are usually shipped in hampers and hauled direct to the railroad station. In this case, there are buyers who are well posted on market quotations and who, upon inspection, generally buy the potatoes from the wagons. On a large platform near the railroad station the potatoes are then repacked from the hampers into barrels which are loaded direct in the cars and immediately rolled to the market. The barrels employed are second-hand flour barrels (Fig. 29, c). They are usually split open at various places to permit ventilation. About 200 barrels, approximately 600 bushels, make a carload. In New Jersey it is customary to ship in barrels while other sweet potato centers prefer to ship direct in ⅞-bushel hampers (Fig. 29, d). George Livingston, Chief of the United States Bureau of Markets, in a recent circular letter from which we draw liberally, states that the Bureau of Markets does not recommend the shipment and sale of sweet potatoes by the weight per bushel. It believes in the sale by weight or by the standard package. The table of the weights per bushel in various states for sweet potatoes will indicate the folly of any attempt to sell by the bushel. These weights per bushel vary from 46 to 60 pounds.

Legal Weights per Bushel for Sweet Potatoes

(Pounds)

Alabama	55	Massachusetts	54	Ohio	50
Arkansas	50	Michigan	56	Oklahoma	55
Connecticut	54	Minnesota	55	Pennsylvania	54
Florida	56	Mississippi	54	Rhode Island	54
Georgia	55	Missouri	56	South Carolina	50
Idaho	50	Nebraska	50	South Dakota	46
Illinois	50	Nevada	50	Tennessee	50
Iowa	50	New Hampshire	54	Texas	55
Indiana	50	New Jersey	54	Vermont	54
Kansas	50	New Mexico	50	Virginia	56
Kentucky	55	New York	54	West Virginia	50
Maine	54	North Carolina	54	Wisconsin	54
Maryland	60	North Dakota	46		

It will be noted also that no difference has been made between the weight-per-bushel of fresh and kiln-dried sweet potatoes.

The Bureau of Markets does believe in the ultimate establishment of standard containers to be used in shipping and marketing sweet potatoes, whether the potatoes are sold by the bushel weight or package.

Containers. The style of container used in the marketing of sweet potatoes will depend on market requirements. For curing sweet potatoes the crate is undoubtedly preferable, but for the early marketing of fresh potatoes the hamper or round basket, if well built, may prove more desirable. In order to prevent misunderstandings, disputes and possibly litigation, the different types or styles of containers should have the same cubical contents. The bushel-crate or basket of 2150.42 cu. inches is now in general use in certain sections of the South and East. Unfortunately, however, other sizes, either slightly larger or smaller than the bushel, are also in common use. There is an opportunity for either the ⅞-bushel hamper or the 12×12×18″ crate to be mistaken for a standard bushel.

In standardizing containers it is axiomatic that where more than one size is adopted, the variation in size should be sufficient to prevent deception. If a bushel-crate of 2150 cu. inches is too small for the economic handling of sweet potatoes owing to package costs, then the 1½ bushel-crate containing 3225.6 cu. inches is suggested as a possible solution. This crate will cost but a few cents more than the bushel-crate, holds approximately 50 per cent more potatoes, is not too large to be conveniently handled in curing houses and *cannot be confused with the bushel.* It has all the advantages of the 12″×12″×18″ crate and none of the objectionable features. It is suggested that experimental shipments be made in a 1½ bushel-crate, having the inside dimensions 13″×13″×19⅛″.

It is easy to profit by the experience of growers and shippers in marketing barrel lots of fruits and vegetables. Prior to the passage of the U. S. Standard Barrel Act, business was badly hampered by the lack of uniformity in the size of barrels. This lack of uniformity was brought about largely through attempts to standardize the weight of the contents. Tennessee establishes 125 lbs. and Massachusetts 150 lbs. as the weight of a barrel of sweet potatoes. In other states, either law or custom demanded other weights per barrel. The problem was eventually satisfactorily adjusted through the enactment of the present law providing for a standard barrel of 7056 cu. inches for fruits, vegetables, and all dry commodities except cranberries and limes, for which special sizes were provided.

The hamper and round-stave baskets so widely used in the United States may be standardized on the basis of the same bushel (2150.42 cu. in.) by the provisions of a bill which soon will be inroduced in Congress at the request of shippers, package manufacturers, and the trade. The standard sizes provided by the bill are ½ bushel, 1 bushel, 1½ bushels, and 2 bushels. About one thousand carloads of peaches were shipped from Georgia alone in this round-stave bushel basket in 1918. The same basket is being sold in several states in the marketing of sweet potatoes. It is a well-known fact that hundreds of carloads of sweet potatoes are marketed annually in bushel hampers.

Frequently the 5-peck (1¼ bushel) packages are taken for 1-bushel packages on the market in the same manner that ⅞-bushel packages masquerade as full-bushel packages. This was the reason that the truck growers of Providence, R. I. abolished their 5-peck package and replaced it with a bushel package (2150.42 cu. in.) standard by state law. They found it unprofitable to compete with products from other states shipped in 4-peck or bushel packages.

The bureau of markets believes in the standardization of packages, including the sweet potato crate (Fig. 29, e) on the basis of the volume bushel (2150.42 cu. in.) and its subdivision or multiples. The adoption of crates of capacity intermediate between 1 bushel and 1½ bushels will only lead to confusion and misunderstanding. This confusion apparently already exists and is repeatedly referred to in the circular letter. Inquiries have been made concerning the use of a 12″×12″×17″ crate on the ground that it will hold a weight bushel of sweet potatoes.

Next to grading, the neatness, cleanliness, and attractiveness of the package has much weight in commanding the highest price. Sweet potatoes should never be shipped in ordinary sacks (Fig. 29, f), as they become badly bruised when handled in this way. When shipping in barrels, during the last of the summer or in the autumn, the ordinary flour barrels with a burlap cover will answer the purpose. However, for winter shipment, the double-headed stave barrel or tight box is used (Fig. 29, c).

Frequently the best looking potatoes are ruined in transit. This is commonly due to the fact that the potatoes are subjected, in the car, to different temperatures from those they have had in the potato house. Without the necessary care, the fluctuations of temperature in the car may be very great, and in this case the potatoes may either soft-rot from excess of heat and lack of ventilation or they may be chilled and subsequently rot. During cold weather the containers in which sweet potatoes are shipped should be lined inside with paper and the cars provided with some means of heating or ventilation as the case may require.

Usually there is very little demand for the Yam type or Southern type of sweet potato in the Northern mar-

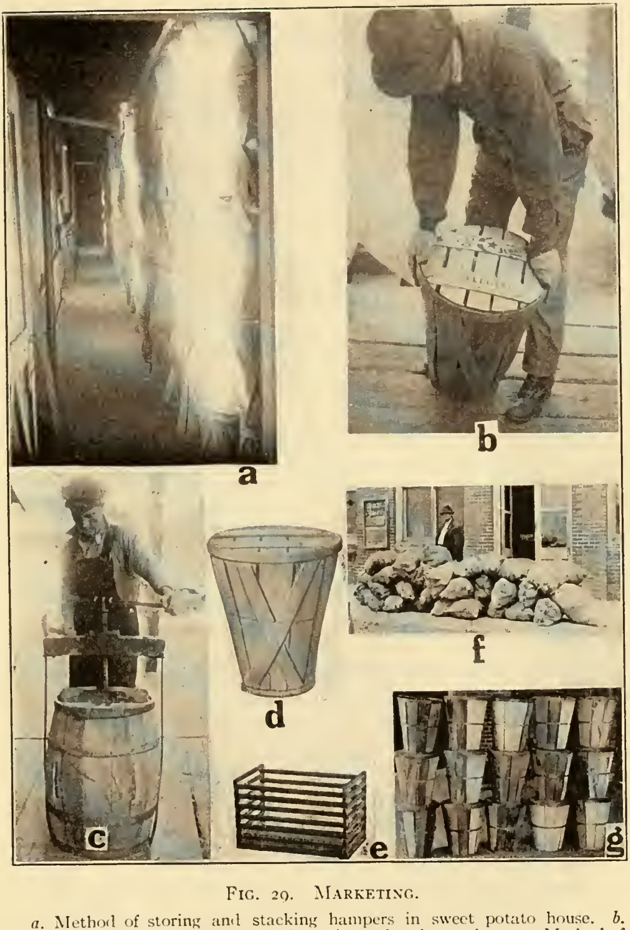

Fig. 29. Marketing.

a. Method of storing and stacking hampers in sweet potato house. *b*. Labeling hampers as they are ready to leave for the market. *c*. Method of packing in barrels. *d*. Hamper used for sweet potato storage and shipping. *e*. Grate used for storage and shipping. *f*. Sacked sweet potatoes ready for shipping. *g*. Incorrect method of stacking hampers in storage house.

kets. However, as soon as the New Jersey district of sweet potatoes is exhausted, dealers look to the Southern sweet potato to supply their markets. It should be borne in mind that dealers will not handle Southern sweet potatoes unless they are thoroughly cured and placed on the market late in the winter when there is a brisk demand.

Care in Shipping

When sweet potatoes are shipped during cold weather and to distant markets, the recommendations as of the United States Department of Agriculture for the Irish potato should be observed.

a. The car should be provided with a false floor. This should be done in order to permit the air to circulate freely under the load from the end of the car and the heater in the center. The false floor should be supported and held in place by two by fours, running lengthwise, and never crosswise of the car.

b. The floor must be of strong enough lumber, so that the weight of the load above will not cause the false floor to sag and thereby cut out the circulation of air.

c. It is also advisable to use false side walls. These should reach to a point not closer than six inches from the roof of the car and yet must extend above the top of the potatoes. The object is of course to permit the free circulation of air from the top of the car to every point around the sides and ends, in the spaces between the car walls and the false side walls, and between the false floor of the car floor. False side walls are used in severe, cold weather. During moderate weather, the false side walls as well as false floor, are not always essential, and the papering may be dispensed with. In cold weather, paper is necessary; the bottom and sides and ends up to the ceiling should be papered, even an extra strip of paper should be placed at the junction of the walls and floors and at the corners. In building the false side walls, or false floors, the space between the false walls and the car walls should not be less than four inches at the ends and two inches at the sides.

d. Every precaution is necessary to prevent the loading of potatoes in any part of the car so as to cut off free circulation of the heated air which comes from the stove up to the ceiling, out over the top of the whole car, down at the ends and back under the false floor to the heater. Moreover, it is also essential to maintain a more or less even temperature in every part of the car to prevent the freezing of the potatoes at the floor and the overheating of those at the top. The temperature of the car should be about the same as that came. That is not less than 45 degrees nor higher than of the sweet potato house from which the potatoes 60 degrees F. If it is difficult to maintain that temperature, it may be necessary either to open the bunkers to allow ventilation, or to close them tight to keep out cold air. It is always advisable with a large shipment to send a man who will take charge of that shipment and attend to the fires and to the ventilation.

e. As with Irish potatoes, if the sweet potatoes are loaded less than three feet from the center of the car, where the stove is located, they should be protected from the direct heat of the stove by a sheet of asbestos or other nonconducting material.

f. It is necessary to guard against over-loading the car. Enough potatoes should be put in to be consistent with safety.

g. The stove should be set up in the middle between the doors and fastened securely to the floor. An ordinary coal stove will answer the purpose. The stove pipe should be carefully wired in place. The regulations of each railroad in this case should be followed. Before loading, the car is heated for at least six hours. This, however, is only necessary in extra cold weather.

h. Sweet potatoes should never be loaded into cars with ice in the bunkers.

i. Comparatively short-haul shipments of potatoes may be made without the use of heaters. This is especially true for shipments made in the South. In this case, however, high grade refrigerator cars should be used. If there is any possibility that the car may have to be heated later, the space between the false floor should be kept clear from all obstructions and the ventilation openings through the ice bunkers' bulkheads should not be papered over.

j. During extra cold weather it is advisable to use not less than two heavy layers of straw with alternate layers of building paper for added insulation between the potatoes, the false floor and car walls.

Shipping Sweet Potatoes Abroad

Because of the perishable nature of the sweet potato, no great effort has been made in the past to ship potatoes abroad. During the last two years, however, enterprising shippers have successfully consigned sweet potatoes to Canada. This was done by taking the extraordinary precautions of properly heating the car until it reached its destination. It has not, as yet, however, been found practical to ship sweet potatoes to Europe. The only attempt ever made was in 1902, when, according to Taylor (105) sweet potatoes were shipped to London and Paris. Some of the potatoes were fresh from the field and some were partially kiln-dried. This was done as an experiment by the United

States Department of Agriculture. Some of the potatoes were wrapped and others were not. The freshly dug potatoes arrived in better condition than those which had been kiln-dried. Taylor, therefore, claims that sweet potatoes freshly dug from the fields could be successfully shipped to London. Before one could embark on such an enterprise, however, more experimental shipments would have to be made before its success could be definitely proved. One season's work on this would hardly justify any practical conclusion. This, however, is not the case with dehydrated or canned sweet potatoes, which are unaffected by shipment, and this should open a new, unlimited industry to the Southern sweet potato grower.

In order to encourage the production of better grade sweet potatoes for the market, all agricultural fairs should offer premiums for the best grades exhibited. The following score card is suggested by Wilson (115).

Sweet Potato Score Card

	Points
Uniformity	35
Smoothness	20
Trueness to type	20
Freedom from blemishes	15
Size (marketable size)	10
Total	100

Sweet Potato Association of America

The above title is as yet a myth, as no such an organization is in existence although local and state organizations are coming into prominence in the United States. The sweet potato industry will not make rapid headway unless our growers organize in a fashion similar to that of the White Potato Association of America. This organization endeavors to unite all who are engaged in the potato industry for purposes of mutual protection, and for the promotion of the potato industry in all its branches. The White Potato Association of America further tries to make the potato more popular for table use through careful grading and packing, thus insuring better prices to the grower. It further tries to utilize all surplus potatoes, to manufacture starch, potato flour, dried potatoes, and all other manufactured products. It also tries to collect and distribute the best available information on both the practical and scientific phases involved in increased yields coupled with decreased cost. Finally, this association tries to increase the per capita consumption of potatoes from 2.6 bushels to 10 or 12 bushels where it should be.

With reasonable prices for cured sweet potatoes assured, the sweet potato growers cannot afford to work singly and single-mindedly. The sooner a Sweet Potato Association of America is organized with aims and purposes such as that of the White Potato Association of America, the more rapidly will the sweet potato take a place such as the white potato is now occupying. If, for some unexplained reason, a national organization cannot be effected immediately, it could at least begin local and state associations. It is doubtful if the sweet and the white potato if increased to their maximum production will ever compete with each other. Each of these two crops have distinct uses and possibilities untold, as a food and for numerous commercial manufacturing purposes.

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