NOVEMBER, 1938 BULLETIN 278

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

SWEETPOTATOES IN KANSAS

PRINTED BY KANSAS STATE PRINTING PLANT
W. C. AUSTIN, STATE PRINTER
TOPEKA 1938
17-5659

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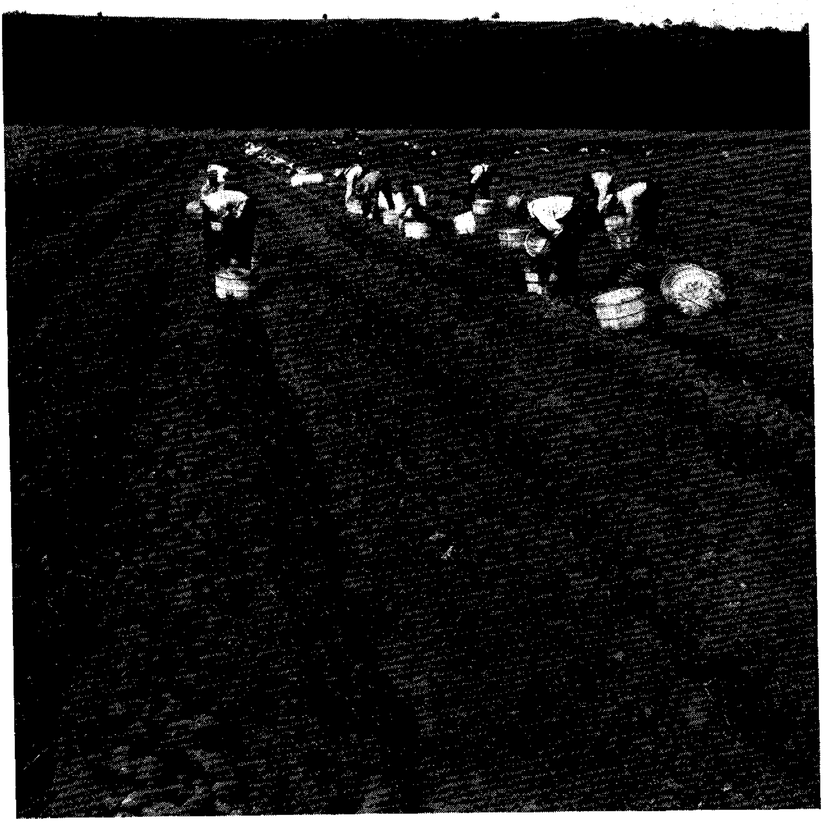

SWEETPOTATO HARVESTING SCENE NEAR MANHATTAN, KAN.

Variety: Little Stem Jersey.
Yield: 450 bushels per acre.

SWEETPOTATOES IN KANSAS[1]

O. H. ELMER

INTRODUCTION

The sweetpotato is commercially the second most important vegetable crop both in Kansas and in the United States, and is exceeded in volume of production only by the Irish potato. Kansas is on the northern border of this country's sweetpotato-growing region. Climatic conditions here are favorable, and a considerable area in the state is suitable for the profitable production of this crop. The largest areas suitable for sweetpotato production in Kansas are located in the Kansas and Arkansas river valleys. Smaller areas where this crop can be produced successfully are present in numerous other localities in the eastern half of the state.

In Kansas the sweetpotato produces best in sandy loam soils. Rather sandy soils may produce high yields and a good type of sweetpotato, but excessively sandy soils should be avoided because they lack necessary soil nutrients. Heavy soils should not be used for. commercial sweetpotato production, for in such soils the roots become ill-shaped and unattractive.

Disease-producing fungi are the most important limiting factors for continued profitable production of sweetpotatoes on any farm. These fungi are disseminated with affected sweetpotatoes and are carried to hotbed and field soils through seed and planting stock. Injury from them can be largely prevented by combining effective disease-control measures with the other farm practices incident to growing and storing this crop.

The purpose of this bulletin is to describe the various cultural operations for producing the sweetpotato crop, to indicate the requirements for curing and storing the roots, and to discuss means for preventing losses from diseases and other pests.

PART I. HORTICULTURAL PRACTICES

Selection of Planting Stock. — The selection of planting stock is an important consideration in the production of sweetpotatoes. The varieties to be grown must be suited to local conditions so adequate yields can be produced. Varieties grown should be those that are desired by the available markets. Sweetpotato seed stocks should be free from root-borne infections of the stem rot, black rot, soil pox, and scurf organisms.

The varieties of sweetpotatoes most commonly grown in Kansas include Little Stem Jersey, Big Stem Jersey, Improved Big Stem Jersey, Porto Rico, and Nancy Hall. Varioua strains of sweetpotatoes have been isolated from established varieties through the

1. Contribution No. 367 from the Department of Botany.

propagation of distinctive vegetative plant variations, and some of these strains have themselves been given varietal names. The variety Priestley is said by its originator to be a selection from Little Stem Jersey. A sweetpotato grown in Kansas is Speakers Special, a variety that originated from the Improved Big Stem Jersey. A similar strain isolated in Maryland is known as the Maryland Golden Sweet.

In Kansas certain varieties, such as Red Bermuda, may produce good yields on relatively heavy soils that are unsuited for the production of Nancy Hall or Jersey varieties of sweetpotato. Red Bermuda, Yellow Queen, Red Brazil and certain other varieties are resistant to stem-rot infection and produce good yields in stem-rot infested soils, where such highly susceptible varieties as Porto Rico or Nancy Hall are apt to fail.

Sweetpotato varieties differ in the length of time required for the roots to reach marketable size. Differences also exist in the ability of different varieites to keep under winter storage conditions. Such differences should be considered in the selection of varieties to be propagated. The grower who desires to produce sweetpotatoes for continuous marketing from early fall until spring may well consider planting a portion of his acreage to varieties that are suitable for the early season market and planting the remaining acreage to varieties that are adapted for storing and later marketing. Nancy Hall, for example, has been used extensively as an early season crop to be harvested when prices are usually high. This variety produces profitable early-season yields in Kansas. Its roots contain more sugars at this season and are consequently more desirable for table use than are the Jersey varieties which contain little sugar until after they are cured.

Some growers find that for their particular field soil or storage conditions, certain varieties of sweetpotatoes shrivel excessively as compared with others. Such differences should be considered in selecting varieties to be stored.

Little Stem Jersey, Nancy Hall and Porto Rico, when kept under good storage conditions, usually remain firm and attractive until in the spring, but under similar conditions of storage, the varieties Common Big Stem and Improved Big Stem frequently shrivel excessively. This is especially true when the roots are stored in baskets or crates. Shriveling becomes more pronounced during some seasons than during others and it has been noted that shriveling becomes especially serious with roots that are harvested when they are comparatively immature.

Varieties that shrivel excessively during winter storage need not necessarily be excluded from the field planting if they can be grown profitably and marketed during the fall and early winter. However, only such varieties as can be stored successfully through the winter should be produced for spring marketing.

Variations Within Sweetpotatoes.--Variations in plant characteristics frequently occur among sweetpotato plants of the same variety. Such variations may be very slight, or may consist of wide differences from the parental type. New variations may be an improvement over the parent variety, or they may be less desirable. Variations from the parental type frequently are propagated through sprout plantings, the new characteristics being transmitted through succeeding vegetative generations.

Varieties in vegetatively propagated sweetpotatoes usually originate as bud mutations commonly known as "bud sports." The mutant bud of a sweetpotato plant or root produces a plant growth that has new and distinct characters. A Red Jersey sweetpotato, for example, was observed in Kansas that bore some yellow-skinned roots in addition to producing the characteristic red-skinned roots. The yellow skin color of the mutant was transmissible to succeeding vegetative generations. A variety known in Kansas as Speakers Special is a mutant from Improved Big Stem in which the flesh and skin color contains more orange and in which there is a greater amount of orange-colored tissue within nodes of the stem at the crown than is the case in the parental variety. Harter[2] reported a mutation of the Haiti variety where the roots have a yellow skin color instead of the red color of the parental variety. A mutant strain of Little Stem Jersey which is highly resistant to surface rot during storage also has been reported by Lauritzen.[3]

Evidence has been obtained that transmissible variations occur among sweetpotato plants of the same variety in such characters as yielding ability, general shape of the roots and resistance to disease. Single hill selections of Nancy Hall were made by the writer in 1932, in a field near Kansas City, where the soil was severely infested with the stem-rot organism. The progeny of these selections has been grown and compared in this field during the past five seasons. The parental stock from which the selections were made had been grown on the stem-rot infested soil of this farm since 1917, and planting stock since 1921 has been obtained by an annual selection of roots from desirable type plants that were free from stem-rot infection. While stem rot was common among the plants in 1932, commercially profitable crops were nevertheless being grown. Newly introduced stocks of Nancy Hall also were grown in this field, but did not produce profitably because of severe losses from the stem-rot disease. It appears, therefore, that resistance of this general stock to stem rot. had been increased through the annual hill selection of plants that remained free from this disease.

The 1932 selections were made to compare the characteristics of individual plants with respect to yielding ability, root shape, and resistance to infection by the stem-rot organism. Some of the "strains" that mere isolated have demonstrated a considerably higher-yielding ability than others. The roots produced by some of the selections have, in general, been short, and blocky in shape, some produced undesirably long and slender roots, while those of

2. Harter, L. L. Bud sports in sweetpotatoes. Jour. Agr. Research, Vol. 33, No. 6, pp. 523-525, 1926.

3. Lauritzen, J. I. A strain of yellow jersey sweetpotato resistant to surface rot (*Fusarium oxysporum* Schlect). Jour. Agr. Research, Vol. 33, No. 11, pp. 1091-1094, 1926.

others were rough and ill shaped. Great variation in general yielding ability or shape of the roots did not occur among the plants within any line when these plants were all growing under similar conditions. A considerable variation in susceptibility to the stem-rot disease was noted between the various lines originating from the single plant selections. No strain of Nancy Hall immune to stem rot has been found, but sufficient differences in susceptibility have been observed to indicate that strains occur in this variety which are highly resistant to this disease. From the past five years' results, it is evident that variability in the general stock existed in 1932, and that through propagation of single plant progenies the more desirable, as well as the less desirable, strains were thus isolated.

Individual differences among the plants of growers' sweetpotato stocks indicate that this plant is not stable under Kansas conditions. The differences that occur among plants within a variety may be due to easily recognized mutations, or they may be due to lesser variations in plant characters which are transmitted to succeeding vegetative generations. A constant selection of desirable plants is necessary in order to maintain maximum desirability of the stock being propagated. Sweetpotato growers in Kansas who do not practice hill selection secure new planting stocks periodically because their old stocks no longer produce the desired yield or root type, or because stem-rot infection becomes too severe. Growers who do practice intelligent hill selection find that the desirability of a stock can thereby not only be maintained indefinitely, but that it can be increased.

Hotbed Construction.— Sweetpotato planntings in Kansas are generally made with sprouts produced in hotbeds. Less frequently the sprouts are grown in greenhouses, and, for late plantings, in cold frames.

In constructing the hotbed, provision must be made for supplying heat to the soil and for protecting the plants from low outside air temperatures. Heat can be obtained from fermenting manure, from fires, or from electricity, The optimum bed temperature for sprout production is approximately 80° F. Sprout growth is slower at lower temperatures and practically stops at 60° F. The bed temperature should never be allowed to rise above 90° F., as serious injury or death of the sprouts results from excessively high temperatures.

Protection from cold air is secured by covering the beds with glass or cloth sash, canvas or cloth tents, or with boards or sheet metal. Suitable frame structures must be constructed to surround the bed and to support the sash, tents, or other covering materials. When opaque covers are used, they must be removed daily after the sprouts have emerged though the sand in order that the plants may receive light.

Hotbeds should be located conveniently, and an adequate supply of water for the plants must be available. A south exposure with windbreak protection toward the north is desirable. Hills that slope towards the south can be used very conveniently for the hotbed site, especially when heating is done with fire and a pit below the level of the bed must be provided for the fire box.

The dimensions of the hotbed should be determined by the bedding area required, the space available for the beds, and the size of the sash, tents, or other materials to be used for covering the beds.

When the bed is to be covered with glass or glass substitute covered sashes, its width is determined by the length of the sash. A standard size for glass sash is 3 by 6 feet, but wider and longer units can be obtained. Home-constructed sash may be fitted with glass or with a glass substitute, as, for example, cloth or canvas,

FIG. 1.—Treating and bedding sweetpotatoes.

Treating with corrosive sublimate solution is done in barrels and the roots are then planted immediately in the hotbed.

The manure-heated beds are covered with light canvas over a frame as shown in the illustration.

and may be made any suitable dimension. The sash may be laid flat over the bed, but preferably should be sloped in order to carry off rain water. If the back wall rises 2 feet in order to give slope, a 6-foot sash will cover a bed 5 feet 8 inches wide. A wider bed costing less per square foot of bed space is obtained by constructing a ridged hotbed roof with sash covering both slopes.

When the hotbed is to be covered with cloth or canvas tent, the necessary structure must be provided for supporting the fabric and for fastening it down securely. The ends of the bed, constructed with boards or other building material, may slope upward from both sides to a ridge as is shown in figure 1. A ridge board should extend the length of the bed to support the tent, and low side walls should be provided for fastening down the sides of the tent.

Some growers use flat-topped hotbed frames 6 feet wide and 16 feet long, constructed of 1- by 12-inch boards. A hotbed of this type is shown in figure 2. The frames are covered with cloth or canvas and cross pieces are supplied at suitable intervals to support the covers.

Heating the Hotbed.— In Kansas the most common method for heating hotbeds is through the use of a layer of fermenting manure below the bed. This means of heating the hotbed, which will be

FIG. 2.—Bedding sweetpotatoes in manure-heated hotbeds. These flat beds are covered with canvas as shown in bed to left.

discussed later in greater detail, has long been in use and has been both an economical and an efficient method for inducing sprout growth. It is, however, becoming increasingly difficult to secure manure, and other methods of providing the required heat are now receiving increasing consideration.

Fire is replacing manure as a source of heat when a sufficient supply of the latter cannot be obtained. The smoke and heat from the fires are sometimes passed under the beds through a pipe or tunnel to heat the soil. Hot water or steam pipes buried in the bed and connected with a central heating plant are occasionally utilized as the source of heat.

A common method of heating hotbeds with fire is to allow the gases and heat from a fire to pass through a pipe buried underneath the soil for the full length of the bed and then out through a flue. The disadvantage of this method is that the heat intensity is not evenly distributed to all portions of the bed. Good sprout growth may occur directly over the pipe where the soil is properly heated, but sprouting is retarded at the edges of the bed which receive insufficient heat. The result is that sprout production is uneven and unsatisfactory. The firebox is sometimes connected with two pipes that run parallel near the edges of the bed, but even heating of the entire bed by this method is also difficult, owing to the tendency to secure unequal drafts in the two pipes.

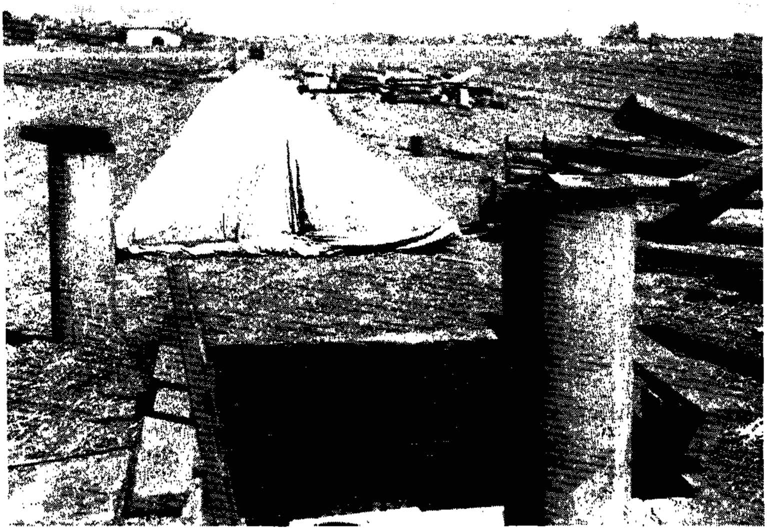

FIG. 3.—A flue-heated hotbed.

A 12-inch pipe from the furnace in the pit parallels the right side of the bed, then by means of a U-turn it reverses its direction and parallels the left side of the bed. The smoke finally escapes through the stack at the left. The stack in the right foreground allows the escape of smoke from a second furnace that heats a hotbed on the opposite side of the pit.

An effective method for heating the hotbed is by means of an underground pipe which carries smoke and heat from a furnace along one side of the bed to the farther end at which point the pipe reverses its direction by means of a U-turn and then carries the smoke and heat back through the bed near the other side to a point near the furnace where the smoke is allowed to escape through a flue. A bed heated by this method is shown in figure 3. The 12-inch pipe from the furnace enters the bed at a depth of 36 inches and at a distance of from 15 to 18 inches from the side. At the U-turn at the farther end it is about 24 inches below the surface and about 11 inches from the sides. After reversing its direction, it leaves the bed at the furnace end at a depth of approximately 10 inches and at a distance of 6 inches from the side. The incline of the pipe and the varying distance from the pipe to the edge of the bed compensates for the gradually decreasing temperature within the pipe. The bed should not be longer than 60 feet or inadequate heating will result near the flue end of the pipe. It should not be wider than 8 feet, as ineffective heating of the center results if the bed is too wide.

A furnace with sufficient capacity to supply the required volume of heat is essential for heating the flue-heated hotbed. Size of the firebox depends on the type of fuel to be used. The inside measurement of the firebox for heating the hotbed illustrated in figure 3, in which wood is used for fuel, is 6 feet long, 3 feet high, and 20 inches wide. The lower level of this firebox is 7 feet below soil level. It is constructed with firebrick held in place with fire clay. A steel firebox originally installed was found inadequate because the iron became red hot and then warped out of shape. The pit, constructed with brick, is 7 feet deep, 5 feet wide, and 6.5 feet long. Two furnaces are installed at the two opposite ends of the pit, one of which heats a second bed extending in the opposite direction from the one shown. The flues from both furnaces are shown in the photograph.

Another method of heating the hotbed with fire is by introducing the smoke and heat from a firebox underneath the bed into a tunnel that extends the full width and length of the bed. The floor of the bed, which is the roof of the tunnel, may be supported on the outside walls of the tunnel and on piers. Supports for glass sash or cloth tents are provided so the bed can be covered. The firebox, in which wood, coal or oil may be used as fuel, should be located at one end of the hotbed. A pipe carrying the heat and smoke inclines upward from the furnace and enters the tunnel at a point approximately three fourths of the distance from the furnace end. Outlet flues are provided in each corner at the furnace end of the tunnel. The smoke and heat thus pass through the inclined pipe to the tunnel and their direction is then reversed so they travel back toward the furnace and out through the flues. Convection currents are sufficiently strong to heat the bed over the distant one fourth area from the point where the heat enters the tunnel.

Electrically heated hotbeds are being used in certain sections of Europe and America where the cost, of electrical current is low. This method of heating the hotbed is as yet not in use extensively in Kansas.

Bedding and Management of the Hotbed.— A sufficient supply of stocky, well-hardened sweetpotato sprouts should be available at the time when field plantings should be made. The production of these sprouts requires the proper management of beds that are suited for this purpose.

Only sound and disease-free sweetpotatoes should be planted in the hotbed. Whenever possible the seed stock should also be of a high-yielding and otherwise desirable strain of the variety. The potatoes used as planting stock should have been hill-selected for freedom from stem-rot infection, for yielding ability, and for type at the time they were dug, or they should at least be from fields where stem rot or other diseases were not prevalent. Stem-rot-infected potatoes generally cannot be recognized in the spring when the potatoes to be bedded are sorted. Badly shriveled or decayed potatoes or those affected with black rot, soil pox, or other diseases should be discarded.

The date of bedding should be so timed that the sprouts can develop to the proper size and still not grow too long by planting time. An average of five or six weeks is required for sprouts to develop sufficiently for planting in the field. Clipping the tops in the bed to prevent excessively long sprouts should be avoided if possible. Where large field plantings are to be made, it is sometimes advisable to bed the sweetpotatoes at successive dates in order that all of the plants may not be ready for field planting at the same time.

Sweetpotatoes that are starting to grow in the bin produce earlier sprouts in the hotbed than do roots that have not started growth at the time they are bedded. Sprout production from dormant seed stock may be hastened by heating the storage room to 80" F. and by supplying humidity to the air for a period of about two weeks before the roots are bedded.

Seed Treatment

The roots that are to be planted in the hotbed should be treated with a fungicide just before they are bedded. The recommended treatment is to immerse them for 10 minutes in a solution of 4 ounces of corrosive sublimate dissolved in 30 gallons of water. This treatment kills surface-borne spores of disease-producing organisms that may cause infection in the hotbed or the field, but the treatment is not effective for killing disease-producing organisms within the tissues of infected potatoes. Roots with disease lesions must. be sorted out before the seed is treated.

The potatoes may be treated in wooden barrels of 50-gallon capacity, the barrels being filled with the sorted roots, after which they are covered with the corrosive sublimate solution. (See fig. 1.) After they have been treated for 10 minutes, the solution is drained away through a hole at the bottom of the barrel and kept for further use. The treated potatoes can be planted immediately in the prepared hotbed. Two barrels may conveniently be used for dipping the sweetpotatoes. During the 10-minute treatment, period, the second barrel can be filled with roots and at the end of this period the solution can be transferred to the second barrel as it is being drained from the first. A third barrel should be used for diluting the corrosive sublimate and for a reserve supply of this solution. After four barrels full have been treated, the solution becomes too dilute and after restoring to the original volume with fresh diluted corrosive sublimate solution, one half ounce of corrosive sublimate dissolved in water should be added to restore the concentration, after which four more barrels of the roots may be treated. The old solution should then be discarded and a new lot should be prepared.

Artificial heat should be available in the hotbed from the time the roots are bedded until the plants are well up. When fermenting manure is used as a source of heat, the beds must be prepared some days in advance, in order that the sand may be warm at the time the potatoes are bedded. When the bed is heated with flues, the fire should be started a day or two in advance of bedding,

Manure that is to be used for heating the hotbed should be prevented from fermenting until after it has been placed in the bed. Only manure, preferably from the horse barn, that, contains a large amount of straw will produce the required amount of heat, When obtained sometime before being needed for the hotbed, it should be piled in broad flat piles, preferably parallel with the bed. If piled too deep, it, will heat and must be forked over at necessary intervals to retard fermentation. It is very important. that the manure be uniformly moist, but not too wet at the time it is put into the hotbed. When too dry, the manure will "fire" and when too wet the process of fermentation and consequently the heating of the bed is retarded.

The quality and the amount of manure in the hotbed determines the amount of heat. that will be produced. Fresh horse manure containing a large amount of thoroughly moistened straw should, under Kansas conditions, be applied in the bed to a depth of approximately 12 inches after being well shaken out and tramped down. It is very important that the manure layer be uniform in thickness in all portions of the bed. Piling the manure directly into the bed from the wagon and then leveling it out is likely to result in an excessive amount of manure due to packing where the manure was piled. Severe injury to the plants sometimes occurs at such places due to the excessive heat that is produced.

Sand or soil that is not contaminated with sweetpotato disease-producing organisms should be used in the hotbed. The sand or soil used during previous seasons, or soil from fields where sweetpotatoes were formerly grown, should be avoided, because it may contain disease-producing organisms. Previously used hotbed frames should be cleaned and then sterilized by wetting them thoroughly with a solution either of copper sulfate (blue vitriol) at the concentration of approximately 1 pound to 10 gallons of water, or of formaldehyde at the rate of 1 pint to 15 gallons of water. The solution may be sprayed onto the frames, it may be applied with a broom, or any other convenient method may be used whereby the frames are thoroughly wetted with the fungicidal solution.

In preparing the bed a layer of sand, approximately 4 inches deep, is leveled over the manure when the heat is obtained from fermenting manure or an inch or two over the bottom of the bed when heating is done with fire. The bed should be allowed to stand until the sand has become warm before the roots are bedded. The sweetpotatoes are laid on the sand, generally parallel with each other, and without being in contact.

Varieties differ in the number of sprouts they produce and the abundance of sprouting determines the distance apart at which the roots should be placed on the sand. Certain varieties, like Nancy Hall, produce relatively few sprouts and can be placed fairly close together. Other varieties like Little Stem Jersey produce large numbers of sprouts and the bedded roots of such varieties should be spaced an inch or two apart in order that the plants may not be so crowded as to become spindling. It requires about three bushels of Little Stem and about four bushels of Nancy Hall roots to produce sufficient plants from two drawings of sprouts to plant an acre. About, one bushel fewer roots are required per acre when the third crop of sprouts is used for planting.

After being laid on the sand the roots are then covered with about 2 or 3 inches of sand. The bed should be leveled and is then moistened by sprinkling with water, after which the hotbed covers are put in place so that excessive loss of heat and evaporation of water are prevented. It is necessary that the sand be kept moist, but not wet. Excessive watering is injurious to the bedded potatoes and the heating ability of the manure may thereby be greatly reduced. A continuous supply of heat at the proper temperature and distributed evenly over the entire bed, an even covering with sand, and uniform moisture will provide conditions favorable for simultaneous sprouting throughout the bed and for a uniform growth of the sprouts. Excessively high temperatures, caused by too active fermentation of the manure or by hot days, may be reduced by ventilation and, if necessary, by watering the beds.

When the sprouts hare emerged, the beds must receive light during the day; they must be properly. ventilated by lifting the sashes during sufficiently warm days in order to induce a stocky growth and in order that the sprouts may become hardened preparatory to being planted in the field. The ventilation that may be given depends largely upon weather conditions, but, the aim should be to induce the sprouts to become stocky and well hardened rather than long and tender.

Planting.— Sweetpotato sprouts should be set on ridges in well-plowed soil at the time when danger from frost has passed. The ridges, which may be thrown up with a listing plow, should be made some time previous to planting in order that any dry soil thrown into the ridge may take up moisture and in order that the soil may have time to settle. It is usually advisable that newly made ridges be packed with a roller before the sprouts are planted.

Plants drawn from the sweetpotatoes in the hotbed are carried to the field in bushel baskets or in other convenient containers in which they can be protected and kept from wilting. Only sprouts that are large enough for planting should be drawn. Those not sufficiently developed should be left to grow for later planting. Disease-infected or weak and spindling plants should be discarded. The selected plants should be arranged with root ends together and they may be tied in bundles of convenient size. Every effort should be made to prevent them from wilting. The baskets filled with sprouts should be immersed in water before being taken to the field and the sprouts should be kept covered with a wet sack.

Sweetpotato sprouts are usually set with a planting machine (fig. 4), although small areas may be set by hand with the use of a dibble. The sprouts should be planted as soon as possible after they are drawn and water should be applied in the trench as they are being set in order to firm the soil around them and to prevent exces-

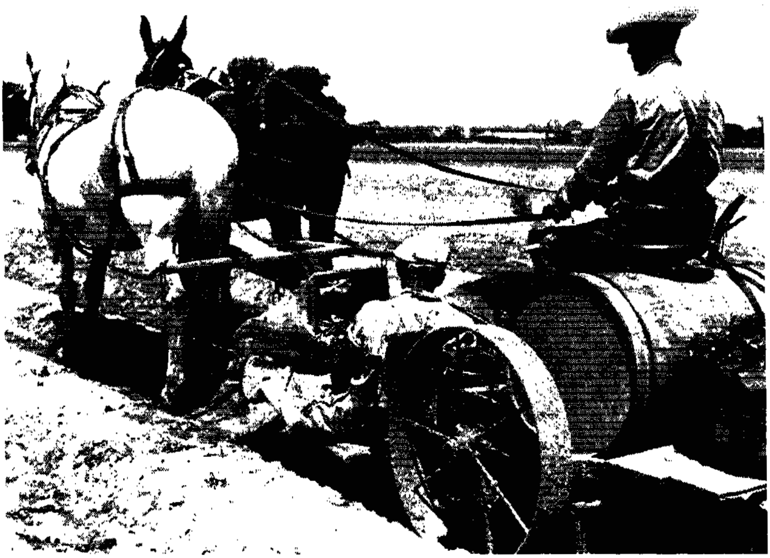

FIG. 4.—Planting sweetpotatoes with plant-setting machine.

Note that with this type of machine the driver sits behind the plant setters and can anticipate necessary stops.

sive wilting. With proper care, sweetpotato sprouts can be shipped or held for several days before being planted, but such treatment. is likely to injure them and to cause reduced yields.

The ideal sweetpotato sprout for field planting is a stocky plant approximately 6 to 10 inches long that has been well hardened in the hotbed through exposure to the weather. In order to avoid injury from wind whipping, the planted sprouts should not extend above the soil more than about 3 inches.

The comparatively early plantings of sweetpotatoes usually produce the highest yields in Kansas. The sprouts should, however, not be planted during unseasonably cold weather. During seasons when such weather occurs at the usual planting date, planting should be delayed until the return of warmer weather. Greater harm results from exposing the newly planted sprouts to cold weather than from a few days' delay in planting.

The first crop of sprouts drawn from the hotbed generally produces a higher yield than do those sprouts that develop later. The earlier date at which they are set in the field is undoubtedly one of the reasons for this higher yield. It has also frequently been noted that the first crop of sprouts contains fewer diseased plants than do subsequent crops. Stem-rot and black-rot infections of plants in the hotbed are apt to be localized at the time the first sprouts develop, but the disease-producing organisms later become more generally distributed in the hotbed. While the first crop of sprouts is preferable to later crops, it is usually necessary to utilize those that develop later. Hotbed space and the matter of economy in the production of the plants must be considered, and the second crop of sprouts generally produces good yields, especially where disease is practically absent from the hotbed. Growers who produce plants for sale should, however, plant as many of the first crop sprouts as possible, rather than sell these and then use later ones for their own field plantings.

Cultivation.— The primary object of cultivating sweetpotato fields is to destroy weeds. Grasses and other weeds should have been prevented from producing seeds in the field during the preceding year or two, as the weed-control problem will thus be greatly simplified.

Any cultivating implement, may be used that is effective in destroying weeds, does not prune or mutilate either the tops or the roots of the plants, and does not flatten the ridges on which the plants are set. More or less hoeing will be necessary, especially between the plants in the row.

A very effective implement for cultivating sweet potatoes is a single-row corn cultivator equipped with knife-like sweeps approximately 24 inches long, in place of the two inside cultivator shovels. The sweeps are attached to shanks near their forward point and are connected to the beam with universal joints so they can be adjusted at any angle or slope. The sweeps slant outward and downward so the blade skims the sloping ridge just below the soil. They may be tilted so that, some soil is thrown onto the ridge for covering small weeds in the row. The regular shovels are used to cultivate the centers of the rows. A cultivator equipped with these sweeps can be used to destroy weeds after the sweetpotato plants have made a considerable growth without the necessity of first turning the vines and without mutilating them.

Harvesting.— The greater portion of the Kansas sweetpotato crop is dug in late September and in October. The crop must be harvested before the advent of freezing weather. A frost that is just. severe enough to kill the leaves will not damage the roots, but injury results to the roots when temperatures fall sufficiently low to freeze the crowns of the plants.

Various methods are used for digging sweetpotatoes and preparing the pack for market or for storage. Any method may be used that fits in with the available equipment and that does not cause injury to the potatoes. The prevention of injury during the process of harvesting and storing is a most important consideration. Heavy storage losses due to soft rot, surface rot, and other decays, as well as shriveling may result when sweetpotatoes are injured during harvesting. Even though decay does not follow, the bruised places remain evident and may become dark-colored. The discolored or decayed spots detract from the appearance of the pack and reduce its sale value. Such losses can largely be prevented by not bruising,

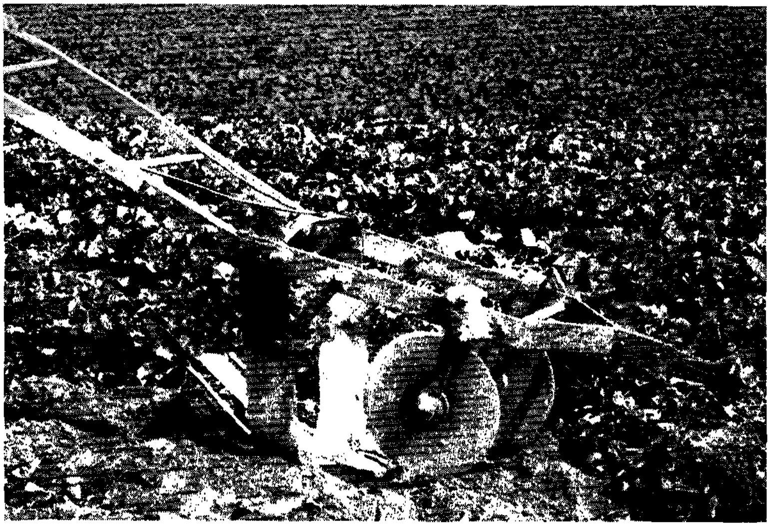

FIG. 5.—Horse-drawn sweetpotato digger.

The digger loosens the plants by cutting at the sides and beneath them and then raising them with the inclined steel flange. The discs cut the vines on either side of the rows.

skinning, or cutting the potatoes at the time they are being harvested.

Sweetpotatoes may be plowed out, or a U-shaped blade attached to a frame as illustrated in figure 5 may be drawn under the plants to loosen the roots. An inclined steel flange extending rearward is attached to the bottom of the U-shaped blade to raise the plants so that the roots are loosened and can easily be removed from the soil. An Irish potato digger, from which the elevator chains have been removed, as shown in figure 6, is a very efficient implement for digging sweetpotatoes. To the rear of the digger shoe there is attached an inclined steel flange to raise the plants and loosen the soil from the roots.

The vines on each side of the row should be cut in advance of digging. Two disc coulters of the type used on the moldboard plow may be attached to a sulky cultivator and used for cutting the vines. When a tractor is used for power, the cutting coulters can be attached to the tractor just ahead of the digger (see fig. 6). Some growers attach mower sickle sections to the two runners of a stone-boat so that when the stoneboat is drawn astride the row, they extend downward into the soil and cut the vines on both sides of the row.

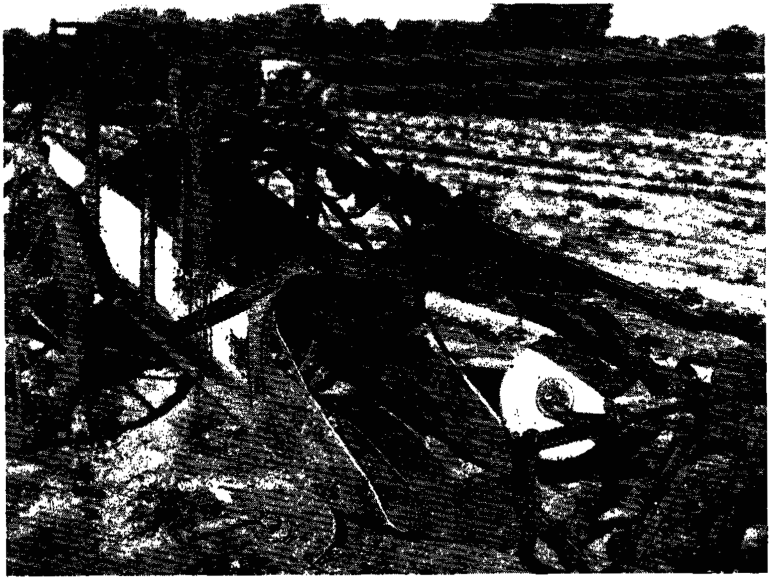

FIG. 6.—Potato-digging machine without elevator chain, for digging sweetpotatoes. Note wide steel flange attached back of shoe to raise the plants and loosen them. Adjustable disc coulters attached to tractor draw-bar cut the vines on both sides of the row.

After the sweetpotatoes are broken from the plants, they are placed on the row to dry before they are gathered into baskets or crates. The secondary and taproots and the stem are broken from sweetpotatoes that are to be marketed immediately, but in order to avoid unnecessary injury, these should not be broken from sweet-potatoes that are to be cured and stored. The yield from two or three rows of sweetpotatoes may for convenience all be piled onto one row from where the potatoes are gathered into baskets or crates. Piling together the roots from more than three rows is not advisable, because in so doing, workmen are likely to throw the potatoes to the pile row from some distance and bruise them.

Table stock packs for immediate marketing are best prepared by re-sorting the potatoes gathered in the field. Those to be stored may also be re-sorted to eliminate badly wounded or otherwise undesirable potatoes and, when diseases are not prevalent, to separate planting and table stock.

Sweetpotatoes should be well dried in the field before they are gathered. Harvesting should, whenever possible, be done during clear, dry weather, and the roots should be dug sufficiently early in the day so they can dry and the skin can harden somewhat before they are picked up. The excess moisture taken into the storage house with undried potatoes is objectionable and the excessive amount of soil that. adheres when they are gathered while damp is undesirable, both on potatoes to be stored and in a pack prepared for immediate marketing.

Hill Selection of Propagating Stock

Sweetpotatoes to be used for planting stock should be selected in the fall at the time the roots are harvested. Growers' sweetpotatoes usually produce plants that are variable in yielding ability and shape of the roots, and stem-rot infection may be present in some degree. It is possible at harvest time to identify high-yielding plants that produce desirable type roots and then only can stem-rot-infected plants be recognized and discarded.

In harvesting sweetpotatoes, the usual procedure, after first loosening the plants from the soil with a digger, is to break the roots from the plants. The roots of plants that bear good yields of desirable-type sweetpotatoes and that are free of stem rot, should be separated for hill-selected planting stock. A practical method for securing hill-selected sweetpotatoes with a minimum of time and effort is for the workmen who remove the roots from the plants to place the apparently superior plants with roots still attached on a row by themselves. The final selection is then made by a person competent to select for the type that is desired and to make the inspections for stem-rot infection as described on page 35 of this bulletin.

It is desirable, especially when stem rot is prevalent, that all sweetpotatoes used for planting should be hill selected for freedom from this disease and also for type and yielding ability. Growers who are not willing to hill select all of their required planting stock should hill select at least a portion of the sweetpotatoes that will be needed for propagation. The plants from these selected roots should be planted in a separate plot from which seed stock can be obtained the following fall and from which hill selections can then again be made. The desirability of the general stock can by this method be increased because diseased and low-yielding plants have been eliminated.

Individual plants sometimes develop whose characteristics are strikingly different from the surrounding plants. When the sprouts from the roots of such variants are planted in separate rows of the same field with the parental stock they can be further compared with the parental variety. Many valuable sweetpotato varieties have been developed by propagating single plants that possessed new and desirable characteristics.

Storage House Construction.— The entire sweetpotato crop usually is not marketed at harvest time, and storage space is required wherein the roots for later marketing and for seed stock can be cured and preserved during the winter. Sufficient storage room is frequently available in portions of buildings already constructed, but in other cases houses must be built especially for storing sweetpotatoes. In providing the needed space, economy must be considered, but it is of primary importance that the stored roots can be cured properly and then preserved throughout the winter. Losses due to shrinkage and spoilage in poor storage houses may exceed, within a few years, the cost of constructing an adequate storage house.

The basic requirements for a sweetpotato-storage house are that it contains the needed amount of space, that it protects the potatoes against outside environmental conditions and rodents, and that it, can be ventilated and heated effectively. The ventilation and temperature requirements for curing and storing sweetpotatoes, and reasons for these requirements, are described elsewhere in this bulletin.

The size of the storage house is determined by the probable amount of sweetpotatoes to be stored. Its general interior arrangement, depends upon whether the roots are to be stored in crates or in bins. Partition walls, which should be slatted, are needed when the sweetpotatoes are to be stored in bins, but are not necessary when the roots are stored in crates or baskets. A false wall with at. least **3** inches of air space should be constructed adjacent to the outside walls in order to permit circulation of air around the stored roots and to prevent the chilling of those roots that come in contact with the wall. A removable false floor with 4 inches of air space underneath and with the boards separated approximately an inch should be provided to allow circulation of air in the lower portions of the bins. These false floors should be easily removable so that dirt and refuse can be cleaned out before a new crop is stored. It is important that the space between the floor stringers should be open at both ends and should connect with the space between outside or partition walls and with the alleyway so that air can circulate around the bins. Continuance of the air passage of the walls with that underneath the false floor is obtained by nailing the lower edge of the false wall at the level of the false floor.

The number and size of individual bins depends upon necessary separation of varieties, seed and table stock, and upon the dates at which roots are to be removed from storage. The danger of decay when the roots are disturbed during the winter is well known to all experienced sweetpotato growers. When portions of the sweetpotatoes are to be removed at intervals during the winter, they may be stored in baskets, crates, or small bins in order that. those remaining need not be disturbed. Many growers, however, prefer to store in bins rather than in baskets or in crates because greater quantities can be stored in the available space and also because in bins there occurs less shrinkage from water loss.

Sweetpotato-storage houses finally are heated with stoves, but heating is sometimes done with hot-water radiators connected with pipes from a central heating system. The radiators or stoves should be located so as to provide an even distribution of heat throughout the room. More than one stove may be required when the storage room is large.

Adequate heating of all portions of the storage room is most easily obtained when the air space between outside and false walls is continuous with the space beneath the false floor. The false-floor-air space should not be obstructed either near the rear wall nor at the alleyway in front of the bins. When the heated air near the ceiling cools, a portion of it descends through the wall space and through the piled potatoes, passes underneath the false floor, and finally emerges at the front of the bin, where it is heated by the stove and again rises to the ceiling.

It is very important, particularly during the curing period, that the storage house be well ventilated so that excessive moisture from the roots can escape. A high humidity is necessary during the curing period, but condensation of moisture on walls, ceilings, or on the roots must, be avoided.

The ventilating system should include both fresh-air intakes near the floor, and vents from the ceiling through the roof. Moisture is most effectively removed from the storage house when the fresh air enters near the floor and then passes through the pile of curing roots. As the air is warmed by the heating stove and takes on moisture from the curing roots, it, rises in the storage room and escapes through the vents. Windows and doors may be used as auxiliary air inlets, but they should not be the only source of fresh air.

The necessary number of fresh-air intakes and vents varies according to the dimensions of the house. A 10-by-12-inch floor ventilator every 16 feet is adequate, provided that at least two intakes be supplied where the wall is more than 16 feet long. One vent, 36 inches in diameter, is of sufficient size for an area of 2,000 square feet of floor space. The flue may be constructed of closely sealed lumber as a square shaft from the ceiling to the roof, but it should be capped with a galvanized metal ventilator head equipped with a vane and movable shield in order that, back pressure due to wind may be prevented. Air intakes and vents should be so constructed that they can be securely closed, and the intakes should be screened against mice and rats.

Curing and Storing.— When sweetpotatoes are to be cured and stored, they should be placed under proper storage conditions immediately after they are harvested. The storage bins should be thoroughly cleaned before the new crop is brought in, special care being taken to remove all old and decayed roots and the litter from the previous year's crop. All surfaces should then be sprayed or fumigated with a fungicide that is effective for killing the spores of disease and decay-producing fungi. Recommended methods for sterilizing the storage house are given later in this bulletin. Before storing the crop, the house should first be well ventilated and the temperature should be at the proper degree for curing at the time the first roots are brought into the house.

All sweetpotatoes that have been detached from the plant or from which smaller roots have been broken are wounded. It is mainly through wounds that decay-producing organisms gain entrance into the sweetpotato, and it is from wounded areas that water loss through evaporation is greatest. The first consideration in curing sweetpotatoes is to provide an environment in which wounds can heal quickly. Such an environment is also required in order that the necessary curing processes can take place within the potatoes.

The skin of an uninjured sweetpotato consists of several layers of corky cells through which very little water can escape. These corky cells also effectively bar the entrance of rot-producing fungi. When this protective covering is broken, new layers of corky cells to cover the wound are produced provided the sweetpotato is in a warm, humid environment.

Injury to a sweetpotato root is followed by an exudation of a milky fluid which dries and hardens. This, however, does not constitute healing of the wound. The walls of a few layers of the exposed cells in the wound next become thickened and hardened and help to prevent evaporation. Surface moisture thus being lessened, infection by decay-producing organisms becomes more difficult because the spores of these organisms require moisture in order to germinate and grow. The actual healing of the wound, however, is due to the production of several layers of new cells just beneath the wounded area. These new cells develop into wound cork and their outer layers become dry and corky. They closely resemble the cells of the original skin and they serve as effectively in preventing evaporation of water and penetration of disease- or rot-producing fungi as did the original skin.

The optimum temperature for curing sweet potatoes is approximately 85° F. The healing of wounds proceeds only slowly at temperatures of 75° F. or below and practically stops at 50° F. The more nearly the storage-room temperature approaches the optimum of 85° F. the shorter is the time required for wounds to heal.

The healing of wounds and curing of the sweetpotatoes is most rapid at a relative humidity of about 90 percent. Newly harvested sweetpotatoes give off considerable water and the problem in curing sweetpotatoes is usually not that of maintaining a sufficiently high humidity so much as that of providing adequate ventilation so that moisture does not collect on the potatoes and in the storage room. It should, however, be recognized that a high humidity is necessary for rapid curing of the potatoes.

At a maintained temperature of about 85° F. and a relative humidity of approximately 90 percent, the curing process is complete in about two weeks. Longer curing periods are necessary when either the temperature or the humidity is lower.

Sweetpotatoes should be stored at a temperature of approximately 55° F. and at a relative humidity of 85 to 90 percent after the curing period is completed. The storage temperature should never be allowed to fall and remain much below 50° F. because injury followed by decay may be caused at such temperatures. Storage at 60° F. is safer than at 50° F., but slow sprouting may result at this higher temperature and the roots lose more moisture and may consequently shrivel excessively.

Important chemical changes take place within the sweetpotato during the curing process. Sound sweetpotatoes lose approximately 6 to 8 percent in weight during this period. Most of this decrease in weight is due to a loss of free water by transpiration, but some is due to loss of carbon dioxide given off in the process of respiration.

The cells of freshly harvested sweetpotatoes contain an abundance of starch, dextrin, and sugars. Some varieties, like Little Stem Jersey, contain a greater percentage of starch, while other varieties. including Porto Rico and Nancy Hall, contain less starch but more dextrin and sugars. Probably the most important chemical change that takes place during the curing process is the breaking down of the starches to dextrin and the conversion of dextrin to sugar. The resulting higher sugar content of the root causes the flesh to have a sweeter taste.

Varieties that have a high starch content, as for example the Little Stem Jersey, are drier and firmer when cooked than are the varieties with a higher dextrin and sugar content, such as Porto Rico and Nancy Hall. A considerable amount of the starch in the Little Stem Jersey is changed to dextrin and sugars during the curing period, but much of it remains as starch, which causes the cooked sweetpotato to remain relatively firm and dry. The roots of such varieties as Porto Rico and Fancy Hall contain more dextrin and sugars than starch when they are harvested and during the curing period practically all of the starch is converted to dextrin and sugar. The flesh of such varieties is moist and soft when cooked. Because newly harvested Nancy Hall sweetpotatoes contain more sugar before being cured, they are then generally considered more palatable than are the starchy varieties like Little Stem Jersey. For this reason the Nancy Hall is commonly grown for early fall marketing, although it. is equally suitable for storing through the winter and for marketing the following spring.

Sweetpotatoes should be left undisturbed during the storage period because wounding followed by decay results when they are moved about. Wounds of the sweetpotato skin heal very slowly at the low temperature and humidity of winter storage, and infection by decay-producing organisms may occur before healing is complete. Spores of decay-producing fungi are generally present in the storage house and they may be carried to the wounded roots by air currents or by fruit flies which are generally present and are attracted to the moist, wounded surfaces. The removal of a portion of the roots in a bin during the winter is unwise unless great care is taken to avoid injuring the remaining ones. The roots should not be allowed to roll over each other while they are being removed from the bin, because skin abrasions result from such treatment and decay will very likely follow. Decayed sweetpotatoes should not be sorted out until the sound roots are to be taken from storage.

For storage of sweetpotatoes some growers have adopted a uniform size crate of approximately one bushel capacity with slatted sides and bottom and with ends of sufficient strength so that the filled crates can be stacked to a considerable height without danger of crushing the lower ones. The stacked crates are piled close together without vacant space between their sides and ends. This method is very convenient for permitting portions of the sweetpotatoes to be removed during the winter. A minimum of space is wasted, shrinkage is much less than when the roots are stored in baskets, the crates can be removed without disturbing the remaining potatoes, and the closely piled crates do not provide hiding places and runways for mice and rats.

Sweetpotato varieties vary considerably in their behavior in storage. Under the same conditions, some varieties, like Red Bermuda and Red Brazil, remain well preserved until the following summer, while other varieties, like Big Stem Jersey, frequently become decidedly shriveled from loss of water. The storage characteristics of varieties should consequently be considered in determining horn long the roots are to be kept before being marketed. Shriveling from loss of water is frequently greater when the roots are held in baskets than when they are piled in a bin, and the storage characteristics of varieties should determine how they are to be stored. Varieties that are subject to shriveling can be preserved better in bins than in baskets.

Sterilization of Storage House.—Disease and decay-producing organisms remain alive for many months in the sweetpotato storage house in soil and refuse from previously stored roots. These organisms should be eliminated before the new crop is stored, by removing all soil and refuse and then sterilizing all surfaces, including bins, crates, and baskets. The storage house should be so constructed that it can easily be thoroughly cleaned. False floors should be removable so they can be taken up and the floor swept clean. No inaccessible spaces between walls where dirt and refuse may collect should be present. After the house is thoroughly cleaned, it should be sterilized in order that the remaining fungous spores may be killed. This may be accomplished through the application of appropriate fungicides, either as a spray or as a gas. Effective sterilization is exceedingly difficult or impossible to attain when the soil and litter have not first been removed, because such materials protect the spores from the effect of the fungicide. Effective sterilization requires that the fungicide be applied to all surfaces in the storage room. When applied as a spray, sterilization results only on surfaces actually moistened by the spray mixture.

Fungicides that may be used for sterilizing the sweetpotato storage house and methods for making the applications are presented below.

Formaldehyde

Formaldehyde is one of the most commonly used fungicides for sterilizing the sweetpotato storage house. It is very efiective in killing fungous spores and its cost is not high. This substance diluted in water at a concentration of 1 pint, in 15 gallons of water can be used as a spray, or formaldehyde can, by appropriate means, be generated as a gas. The formaldehyde solution in water can be safely used as a dip for sterilizing previously cleaned crates or baskets. This solution applied with a broom may also be used for scrubbing and thus sterilizing walls and floor.

The most practical method for disinfecting the sweetpotato storage house is through fumigation with formaldehyde gas by the formaldehyde-potassium permanganate method. Formaldehyde vaporizes very rapidly when the solution is brought in contact,with potassium permanganate and an exceedingly strong dosage of formaldehyde gas may thus be produced.

Effective sterilization through the chemical action of formaldehyde can occur only in the presence of moisture. The surfaces within the house must be moistened and the house should then be closed for several hours before the fumigation is made. Baskets, boxes, crates, or other equipment used for harvesting and storing the crop may be left in the storage house during fumigation. Such equipment should first be cleaned and all surfaces moistened just previous to fumigation.

The dosage that is required for fumigating by the formaldehyde-potassium permanganate method is obtained by using 3 pints of formaldehyde and 23 ounces of potassium permanganate for each 1,000 cubic feet of space. The cubic contents of the storage house are obtained by multiplying its length by its width and this product is multiplied by its height. A room 20 by 10 by 10 feet, for example, contains 2,000 cubic feet and requires 6 pints for formaldehyde and 46 ounces of potassium permanganate.

The formaldehyde gas may be generated in galvanized or enameled pails of 3 or 4 gallon capacity. Earthenware crocks may be used if such pails are not available, but glass containers should not be used because the heat produced during the reaction may break them. A pail should be provided for every 2,000 cubic feet of space and they should be distribued in different parts of the house.

Not more than 46 ounces of potassium permanganate is placed in any one pail. For every 23-ounce portion of the potassium permanganate, 3 pints of formaldehyde are measured into a jar, and the jars are then placed alongside the pails. When everything is in readiness, the formaldehyde is poured onto the potassium permanganate in each of the pails. The operator should begin with the pail farthest from the door, and, working rapidly, should quickly complete the job and get out of the door and close it as soon as possible. The poisonous fumes are given off as soon as the formaldehyde comes in contact with the potassium permanganate. This chemical action generates considerable heat and causes boiling, which in turn speeds up the reaction. The containers must be sufficiently large, otherwise boiling-over may result.

It is necessary that the storage house be kept tightly closed during the fumigation period so as to confine the gas. Formaldehyde gas fumigation is not recommended for sweetpotato storage rooms In the basement of dwellings unless the house can be vacated during the period of fumigation.

After the generation of the gas the house should be kept closed for at least 12 hours, and preferably for 24 hours. At the end of this time, doors, windows and ventilators should be opened from the outside and the fumes should be allowed to escape before the house is entered. After being thoroughly ventilated, the house is ready for storage of sweetpotatoes.

The cost of fumigating by the formaldehyde-potassium permanganate method depends upon the volume to be fumigated and upon the price of the required chemicals. At a cost of $1.62 per gallon for formaldehyde and 40 cents per pound for potassium permanganate, the cost of chemicals necessary for fumigating 1,000 cubic feet is $1.19.

Copper Sulfate

Copper sulfate, also known as blue vitriol, may be applied as a spray for sterilizing the sweetpotato storage house or hotbed frames. The copper sulfate crystals are dissolved in water at the rate of 1 pound to 20 gallons of water. This chemical is corrosive to metals and the crystals should be dissolved in wooden containers or in earthenware crocks. This solution may be sprayed onto all surfaces within the storage house and it may be used for sterilizing baskets and crates.

Sweetpotato Certification.— Provisions have been made by the Kansas State Board of Agriculture, as well as by agencies in other states for certifying sweetpotatoes that meet the required standard of varietal purity and freedom from diseases and insects. Certified seed stock can be sold for a higher price than when not certified, and the certification provisions are thus an incentive for producing a better grade of seed stock. Seed certification is an aid to growers who desire to purchase good planting stock and who realize that the added cost for good plants is preferable to the lower cost of plants, a large portion of which may be infected with disease-producing organisms.

The following provisions regulate the certification of sweetpotatoes in Kansas:

"Should any grower desire to secure inspection and certification of sweet potato plants, the following regulations are applicable to such inspection and certification :

(a) Any grower in the state of Kansas may make application for inspection.

(b) Two (2) inspections will be required, one in the field prior to harvest and another prior to disposal of the seed stock.

(c) An inspection fee of $10 and necessary expenses incident to such inspection shall be charged to the grower. Should the first inspection disqualify the field, a second inspection will not be made.

(d) If the sweetpotatoes pass inspection in the field and in the bin, a certificate will be issued to the grower. In disposing of his certified seed stock, he will attach a copy of the certificate to each separate basket, crate or container holding such certified sweetpotatoes. These copies, are to be furnished by the inspector without charge to the grower.

(e) The requirements for certification shall be:

(1) Varietal purity. No tolerance of other varieties shall bc allowed and plants of other varieties must be rogued out. Failure to do so will disqualify.

(2) Freedom from sweetpotato weevil.

(3) Freedom from stem-rot disease. More than two (2) percent infection will disqualify.

(4) Freedom from black-rot disease. More than two **(2)** percent infection of the tubers will disqualify.

(5) Freedom from all other diseases, including scurf, soil-pox, charcoal-rot, etc. More than two (2) percent infection will disqualify.

(f) A total maximum of more than four (4) percent of all diseases will disqualify.

(g) In addition to the above regulations the grower will comply with the following, and upon request from the duly authorized inspector, will sign an affidavit to the effect that:

(1) He has treated his seed with a solution of 1 ounce of corrosive sublimate to *8* gallons of water for 10 minutes before bedding.

(2) He has used new, clean soil in his hotbed.

(3) He has sterilized the framework of his hotbed with a wash of one pint of formaldehyde to 30 gallons of water, or with some other fungicidal chemical approved by the Kansas Entomological Commission.

(4) He has hill-selected the seed stock for his own planting to avoid stem rot and to breed a better type and higher-yielding strain.

(5) He has, before storing the sweetpotatoes, cleaned the storage house and sterilized it with formaldehyde gas, copper sulfate spray, or by some other method approved by the Kansas Entomological Commission.

(6) He will not sell or offer for sale as certified sweetpotatoes any roots that have not passed inspection.

(7) He will conform to any additional regulations that the Commission may see fit to prescribe."

Marketing.— The problem of marketing the sweetpotato crop profitably is of as great importance to the grower as is the problem of growing it. Kansas growers have no sales organization at present and every grower must either find his own distant market or sell locally for the best price he can obtain. Such marketing conditions are not conducive to a considerable extension of sweetpotato acreage, even though considerable areas of Kansas are well suited for producing this crop.

When sweetpotato harvesting in Kansas gets well under way in September or early October, local sweetpotato prices, which are usually high at the beginning of the season, generally drop to a point considerably below their price at terminal markets. In the past this condition has resulted, even in seasons of short crops. It is due to the glut caused in the local markets by a general disposal of either the entire yield from growers who have no storage facilities or the poorer grades from growers who have such facilities, but desire to store only the better grades. Frequently the market price in the larger cities near by is lowered sharply by shipments from distant sweetpotato-growing areas where prices are even lower. Growers should, owing to these conditions, be prepared with storage space to prevent being forced to dispose of their crop at the low prices that are usual in the fall and early winter.

Sweetpotato prices rise during the winter and good prices can usually be obtained from January until late in the spring. Storing sweetpotatoes until January or later is usually profitable, provided the roots are stored properly so that decay or excessive shrinkage is prevented.

More sweetpotatoes are grown in Kansas than can be consumed locally, and a portion of the crop must be sold to distant markets. Trucks are becoming increasingly important in the distribution of sweetpotatoes, even for long distances. Some growers deliver local and interstate shipments with their own trucks, but distant, truck shipments are most generally made by commercial truck operators. Transport trucks with heating facilities for winter deliveries are equipped to haul sweetpotatoes during practically the entire marketing season.

Railway carlot shipments for distant markets are usually made either F. O. B. shipping point, in whick case the selling price is known before the sweetpotatoes leave the farm, or by consignment; the price to be received not being known until the carload is sold at the terminal market.

Sales of sweetpotatoes in Kansas could be greatly extended by a selling agency capable of filling carlot orders throughout the winter and spring. Such a selling agency, whether or not operated by a growers' organization, would be in a better position to locate distant markets and to sell to them than are individual growers. Wholesale distributors in distant markets who require successive carlots of sweetpotatoes throughout the winter will deal with a sales agency that can supply such shipments, but, make no effort to purchase from individual growers. The sweetpotato sales organization should have central storage houses with railway car-loading facilities in those localities where considerable acreages of sweetpotatoes are grown, so carlot shipments can be made in the winter. A strong sweetpotato sales organization could become a great help to more orderly marketing, especially in the fall. It could assist greatly in securing higher sales prices for the crop, and in so doing it would encourage the extension of sweetpotato acreage in Kansas.

Sweetpotatoes in Kansas are generally marketed in bushel baskets containing 52 pounds. Barrels or hampers used in certain other states are not used here. The sweetpotatoes should be sorted into clean baskets just before they are delivered and care should be taken to remove dirt, decayed or injured potatoes and undesirable or ill-shaped roots. For certain markets that will pay for packing a fancy grade, the potatoes should be graded, but whether the roots are graded or not, they should be put up in as clean and attractive a pack as possible. Repeat orders extending through successive years are being obtained from pleased customers by growers who prepare a superior pack. The extra care that is taken to prepare such a pack not only retains a market outlet for the future, but usually also results in a somewhat higher immediate selling price.

Marketing Grades for Sweetpotatoes

The U. S. grade standards for sweetpotatoes, adopted May, 1926, by the Bureau of Agricultural Economics, United States Department of Agriculture, list, the requirements for the grades U. S. No. 1, U. S. No. 2, U. S. Fancy and Unclassified.

U. S. No. 1 grade consists of sweet potatoes of similar varietal characteristics that are not badly misshapen and must be free from disease, decay, freezing, scald, insect, mechanical or other injuries or from secondary rootlets or growth cracks and must not be misshapen or dirty. The diameter shall not be less than 1 3/4 inches nor more than 3 1/2 inches and the length shall not be less than 3 inches nor more than 10 inches. Not more than 10 percent by weight may not meet the grade or the size requirement, of which not more than 5 percent of the potatoes may have serious defects or be below the minimum size and not more than one fifth of this amount, or 1 percent, shall be affected with soft rot.

U. S. No. 2 grade shall consist of sweetpotatoes of similar varietal characteristics which are free from diseases, injuries, etc., as required for the U. S. No. 1 grade. The diameter shall not be less than 1 1/2 inches nor more than 4 inches. Not more than 10 percent by weight of the potatoes may not meet the grade or the size requirement, of which not more than 5 percent may be below the minimum size. Not more than 1 percent shall be affected with soft rot.

U. S. Fancy grade shall consist of sweetpotatoes of similar varietal characteristics that are firm, smooth and well shaped and that are free from diseases, injuries, etc., as required for the U. S. No. 1 grade. The diameter shall not be less than 2 inches nor more than 3 1/2 inches and the length shall not be less than 3 inches nor more than 6 inches. Not more than 10 percent by weight of the potatoes may not meet the grade or size requirement, of which not more than 5 percent may fall below the minimum size. Not more than 3 percent shall be allowed for defects causing serious damage and not more than one third of this amount or 1 percent shall be affected with soft rot.

Unclassified shall consist, of sweetpotatoes which are not graded in conformity with any of the above grades.

PART II. SWEETPOTATO DISEASES AND THEIR CONTROL

Fungi are plants that have a relatively simple structure. Their vegetative or mold growth, known as mycelium, in general consists of a single row of cells that are attached end to end into threads which become greatly branched. The mycelium is a very delicate structure, and its growth and development requires moisture, protection, a proper temperature and an available source of suitable food materials. Its growth requirements are similar in this respect to the requirements for vegetative growth of the sweetpotato and of other higher plants.

Reproduction in the fungi is either through spores or through sclerotia. The spores, which in different species of fungi are borne either directly on the mycelium or in variously shaped fruiting bodies, serve the same function for the fungi as seeds do for the higher plants. Some fungi produce hardened structures known as sclerotia, which consist of tightly interwoven masses of mycelium. The sclerotia can withstand unfavorable environmental conditions as drought, cold and heat, and by means of them the fungus can survive conditions under which the mycelium dies. Reproduction of fungi by sclerotia is asexual (vegetative) and in this respect sclerotia have a function similar to that of bulbs, corms, or tubers, through which certain higher plants are reproduced vegetatively.

The majority of fungi grow on decaying vegetable matter, but some of them grow on living plants. When they grow into the stem or root tissues of the sweetpotato or other plants, they produce an injury that results in a diseased condition. The injury produced may be due to actual invasion and destruction of the cells, it may be caused by the plugging of water-conducting cells, or it may result from water-soluble substances produced by the fungus that are toxic to the cells. These toxic substances may cause harmful effects to the plant, even at considerable distances from the mycelium.

Disease-producing organisms that attack the sweetpotato are disseminated from place to place by means of spores, sclerotia and by mycelium in affected roots and sprouts The fungi may also be carried about in soil, on farm implements, or on crates and baskets used for harvesting storing or marketing the roots.

The most serious diseases of the sweetpotato in Kansas, stem rot, black rot, soft rot, and soil pox, are caused by fungi. All four of these diseases occur on the plants in the field. The organisms causing black rot and soft rot, also attack stored roots and are the most serious diseases of stored sneetpotatocs in Kansas.

Disease-producing organisms may cause the death and decay of locally-invaded areas of the affected plant, as is the case in black rot, or soil pox. In other diseases, as in stem rot, the organism invades and destroys a large part of the plant's water-conducting tissues, and, in addition, possibly produces a toxic substance that becomes distributed through and has a harmful effect upon the entire plant.

Stem Rot

Stem rot of sweetpotatoes, caused by both *Fusarium batatis* Woll. and F. *hyperozysporum* Woll., is the most, destructive sweetpotato disease in Kansas. Both species of Fusarium cause similar symptoms in affected plants, and only by a laboratory test can their identity be established.

Sweetpotatoes are generally grown in light, sandy soils in Kansas and in the other northern border states of sweetpotato production, including Iowa, Illinois, Maryland, and New Jersey. It is in such soils that the stem-rot, organism becomes most prevalent, and destructive. The stem-rot-susceptible varieties, Porto Rico, Nancy Hall, Little Stem Jersey, Big Stem Jersey, and the selections that have originated from Little Stem and Big Stem Jersey, are the most commonly grown varieties in these states. Varieties resistant to the stem-rot disease that produce high yields and that possess desirable table quality have not been introduced, Such varieties are much needed, especially for fields that are severely infested with the stem-rot fungus.

The stem-rot fungus may live over winter as spores or as mycelium in the tissues of affected stored roots, and it may remain alive for indefinite periods in field or hotbed soils. The sand or soil in hotbeds becomes infested with the stem-rot fungus when infected sweetpotato roots are planted therein. Field soils are most commonly infested with this fungus by setting out diseased plants.

The soil-borne stem-rot, fungus gains entrance to the sweetpotato plant chiefly through wounds. Every sprout is wounded at the time it is drawn from the mother root in the hotbed, and wounding of the plant in the field may occur by cultivation, by insects or rodents, or by the vines being whipped about by the wind. Many healthy sprouts planted in stem-rot-infested soils become infected through wounds early in the season. Later infections, while usually not so numerous, may occur throughout the season.

When young plants in the field are attacked, they frequently die within a few days after the first symptoms become recognizable. When older plants become infected, they may remain alive to the end of the season, but in many cases some or all of the vines die. A field where the stem-rot fungus has caused the death of a large number of plants is illustrated in figure 7. When vines are killed after sweetpotatoes are well developed, premature sprouts are frequently produced from these roots before harvest time.

The stem-rot fungus invades the fibrovascular bundle elements (water-transporting tissues) of the stem of the sweetpotato plant and this invasion causes a brown or black discoloration of the normally light-greenish-colored fibrovascular bundle tissues as shown in figure 8. The fibrovascular tissues are located within the stem and roots at a short distance below the surface. The dark-colored fibrovascular bundles characteristic of diseased plants can be recognized after cutting off or splitting the crown or stem of such plants. The diseased tissues within severely affected stems are frequently so blackened that they may be detected through the epidermis from the outside. The diseased area may extend several feet along the stem, but it is usually evident only within a foot. or less from the crown. The infection frequently extends down from the crown into the sweetpotatoes, but the fibrovascular bundles of these fleshy roots are as a rule not discolored unless the aboveground part of the plant is dead or is very severely affected.

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FIG. 7.—A very poor stand. Nearly all of the plants were killed by the stem-rot organism.

All buds of the sweetpotato root are connected with fibrovascular bundles, but only a portion of these buds may become invaded with the stem-rot organism. When the fungus has not progressed to all parts of an affected root, the noninfected buds produce stem-rot-free sprouts.

The leaves of a sweetpotato plant affected with stem rot turn yellow and the plant becomes stunted. Yellowing is first noticeable on basal leaves. All leaves of highly susceptible varieties like Nancy Hall may become yellow, and such plant's soon die. Affected plants of the Jersey varieties exhibit yellowed leaves, but yellowing is not so general as with Nancy Hall. Just before plants of the

Jersey varieties die, the vines wilt and the leaves die and turn brown without first becoming markedly yellowed.

FIG. 8.—Crown of stem-rot-infected plant at right, showing dark-colored tissue within the stem when the plant was split in two longitudinally. A healthy plant is shown at the left.

The sprouts from disease-free roots in the hotbed may become infected when the stem-rot fungus is present in the hotbed sand or soil. Wounding of the bedded roots occurs when sprouts are drawn for field planting, and through these wounds the fungus can enter the bedded roots and thus infect the sprouts that are later produced from them. The process of drawing the first crop of sprouts also tends to distribute the pathogen more generally through the bed. Because of this, the second crop of sprouts drawn from the hotbed frequently contains a larger percentage of stem-rot infection than does the first crop.

Sprouts affected with stem rot in the hotbed may have yellow leaves, although such yellowing does not always occur. The blackened fibers are present in the tissues of the stem, and this discoloration is evident from the outside through the epidermis of the white stems of the sprouts.

Discoloration of the fibrovascular bundles of the sweetpotato root that is similar in appearance to stem-rot infection may also result from other causes. Frost injury, chilling, and other injuries may cause a darkening of these tissues. The recognition of stem-rot-infected sweetpotato roots in the bin is, as a rule, not certain because symptoms of infection are usually lacking and also because where darkening of the fibrovascular bundles does occur, it may not be due to the stem-rot fungus.

Stem rot of sweetpotatoes is controlled by employing preventive measures designed to guard against the infection of healthy plants or roots. Noninfected roots and sprouts should be planted, and precautions should be taken to prevent subsequent infection. Plants or roots that are infected cannot be cured by external applications of fungicides.

Sweetpotatoes bedded for the production of sprouts should be free from stem rot. When diseased roots are bedded the organism frequently, though not in all cases, grows into and thus infects the young sprout. Infected sprouts can seldom be recognized and discarded, and they are consequently planted in the field. Such sprouts usually die early in the season, and because of them, the field soil becomes contaminated with the stem-rot organism.

Sweetpotato seed stock should be selected at harvest time from stem-rot-free hills. The seed should preferably be obtained through hill selection in which only roots from noninfected plants should be selected. All plants in which the tissues below the epidermis have a brown or black discoloration should be rejected. When hill-selected stock is not available, the roots selected for bedding should be from fields where stem rot was not prevalent. Certified sweetpotatoes or sweetpotatoes from fields that contained very little infection should be used when hill-selected sweetpotatoes are not available.

Sweetpotato roots should be surface sterilized with corrosive sublimate solution before being bedded, in order to kill spores of the stem-rot fungus and of other disease-producing fungi that may be present. Directions for this treatment were described on page 13 in this bulletin.

Attempts have been made to prevent stem-rot infections through the wounds that result on the sprouts when they are drawn, by dipping the lower end of the sprouts into a fungicidal solution and thus coating the wounded areas with this protective material before the sprouts are set in the field. The fungicide Bordeaux Was recommended for this purpose by the North Carolina Agricultural Experiment Station in 1929. Several years' investigations of dipping sprouts for stem-rot prevention were made in Kansas beginning in 1928. The tests were made with various concentrations of Bordeaux and in addition sprouts were dipped in various zinc, copper, sulfur, and both organic and inorganic mercurial compounds. The sprouts were treated just before being planted and were set in moist soil with addition of water from the planting machine. Stem-rot infections occurring shortly after planting have been considerably reduced by certain of these treatments, but injury frequently resulted to the plants themselves. Yields from the treated plants were frequently less than from the untreated control plants, even where stem-rot infection Was reduced by the treatment.

A fungicidal treatment for sweetpotato sprouts that prevents stem-rot infections and that is not injurious to the plant itself would be very desirable. Treatments under Kansas conditions with the fungicidal substances that were tested are, however, not advisable because of the likelihood of injury to the plants.

Black Rot

Black rot, caused by the fungus *Ceratostomella fimbriata* (E. & H.) Elliott, is one of the prevalent diseases of the sweetpotato. This fungus attacks all underground parts of the plant and causes surface decay of the roots, both in the field and in the storage house. Growing plants may become infected both in the hotbed and in the field. Stem rot is the only disease which is more destructive to sweetpotato plants in the field in Kansas. As a storage trouble, black rot is exceeded in importance only by the soft-rot disease.

The black-rot fungus causes somewhat circular, dark-colored, dry or corky decayed areas on the surfaces of affected roots, either when they are growing in the field or when they are being held in storage. This disease causes localized lesions and is in this respect different from the stem-rot disease in which invasion of the causal fungus penetrates within the tissues of stem, crown, and roots, but does not cause external lesions. The black or greenish-black lesions of black rot may vary in size from small spots to rather extensive areas of infection. Black rot does not cause a general decay of the affected roots, but soft-rot-producing fungi, which may cause a complete decay, frequently gain entrance into the roots through the black-rot lesions.

As the black-rot fungus invades the underground stems of the growing sweetpotato plant, it penetrates deeply into the stem, and the affected tissues are killed and become black and decayed. (Fig. 9.) Infections in the hotbed frequently occur before the sprout has emerged through the sand. When such newly developing sprouts become infected, they usually are killed. Sprouts that have emerged through the soil before becoming severly infected, frequently produce side roots above the affected area and such sprouts may survive and produce vigorous plants, even though the stem is affected below. Aboveground evidences of the diseased condition cannot

FIG. 9.—Black rot on sprouts in the hotbed. Note that some sprouts were killed. Sprouts having rootlets above affected areas may survive, but should not be planted. This disease can be prevented.

always be seen, but leaves of severely affected sprouts may be yellowed, giving them a sickly appearance.

Black-rot infections of the sweetpotato plant growing in the field may have originated in the hotbed or may occur in the field. Growers usually do not transplant, black-rot infected sprouts intentionally, but when the disease is prevalent, numerous affected sprouts may escape detection and may then be transplanted in the field. Sprouts that are free from black-rot infection when planted may later become infected in the field through black-rot fungus that was carried on the plant from the hotbed, or the plants may become infected by black-rot fungus that has persisted in the field soil since the past season. Infection of plants in the field usually is not so prevalent as in the hotbed because older plants are not so susceptible as are the young, tender sprouts in the bed. Infection of the roots in the field may, however, be very common.

The black-rot fungus lives over winter within affected lesions on stored roots; it also may live in field or hotbed soils on decaying sweetpotato or other plant refuse, or it may live from one season to another in the spore form. This fungus produces three kinds of spores. Two of these (the colorless conidia and the ascospores) are borne in large numbers and may germinate immediately and cause infections. A third type of spores (the olive-brown conidia) is a thick-walled resting spore that is resistant to unfavorable environmental conditions. These thick-walled spores can remain dormant through the summer in the storage house and may later germinate and produce infections. Infection of the stored roots may originate in the field before harvesting, or the potatoes may become infected through the germinating spores that are present in the storage house.

The black-rot fungus usually infects sweetpotato plants or roots through wounds, although it is probable that this fungus can also at times penetrate uninjured tissue. Wounds through which infections may occur in the hotbed or field may be caused by insects, burrowing animals, or through cultural operations. The roots in the storage house may be injured by insects, rats or mice when they are present, or through handling when roots are removed from the bin.

The control of the black-rot, disease is achieved by preventing infection of the sweetpotatoes in storage, in the hotbed, and in the field. Infections in storage can be prevented by supplying good storage conditions, as has been previously described. Only black-rot-free roots that have been treated should be bedded and only sand or soil that is not contaminated with the black-rot or other disease-producing fungi should be used in the hotbed. Owing to the fact that this fungus can persist in the soil from one season to the next, the sand or soil used for the hotbed should be changed and the hotbed frames should be sterilized every year. Every effort should be made to prevent field soils from becoming contaminated with fungi capable of infecting the sweetpotato. These fungi should not be introduced to the field soils through infected sprouts, and sweet potatoes should not be grown year after year in the same field, because such procedure results in the accumulation and increase of the black-rot and other disease-producing fungi.

Soft Rot

Soft rot of sweetpotatoes typically a disease of the root in storage, is the most prevalent and destructive of the diseases that affect stored sweetpotatoes. The roots may also become infected in the hotbed or in the field, and the soft-rot fungi may sometimes become very destructive to sweetpotatoes in the soil. Infections occur through wounds. After the fungus gains entrance to the root, it penetrates rapidly and may cause decay of the entire root in a very few days. The rot consists of a soft decay of the invaded tissues, usually causing their complete disintegration.

Soft rot is caused by fungi of the genus Rhizopus, particularly the species *Rhizopus nigricans* Ehrb. and *R. tritici Saito.* Both fungi cause a similar type of decay, but they differ somewhat in environmental requirements for optimum growth.[4] *R. nigricans* prefers a temperature of from 42° to 68° F., while *R. tritici* grows best at the higher temperature of 86° F. Both species may infect the sweetpotato roots at temperatures near 68° F.

A combination of high humidity in storage or a moist soil in the field with low temperatures causes the sweetpotato root to be especially susceptible to soft rot. Soft rot frequently appears soon after the sweetpotatoes are placed in the storage house. This is true particularly when temperatures are kept too low during the curing period, at which time the roots are especially susceptible to infection. When suitable conditions prevail for the development of soft-rot fungi, including high humidity, low temperature, and injuries to the roots occur, the disease may continue to develop throughout the storage period.

The fungus *Rhizopus nigricans* and other species of Rhizopus are capable of growing on ripe berries, apples, corn, bread, and on other vegetable matter in addition to the sweetpotato. Black mold on bread, ripe berries, and the moldy, cottony growth on soft-rot-affected sweetpotatoes are spore-producing structures of the fungus. The spores are borne in great numbers and, being carried by air currents, on vegetative matter, or on other objects that are moved about, the fungus becomes widely distributed. Two kinds of spores are produced, one of which (the sporangiospore) is borne in great numbers from the surfaces of infected areas. The other spore type is a resistant structure (the zygospore) by which the fungus can live over long periods when the environment is unfavorable to fungous growth. When environmental conditions again become favorable, the zygospores produce sporangia that bear spores, which germinate and may produce infections of the sweetpotato. After infection has occurred, a period of only a very few days is required until the soft-rot fungus produces large numbers of spores which are capable of causing new infections. The fungus is thus capable of multiplying very rapidly.

Owing to the fact that soft-rot infections occur through wounds, it is very important that injuring the roots be prevented wherever possible. Unnecessary bruising and cutting of the roots should be avoided during harvesting. The roots should be given proper curing and storage conditions and should be allowed to remain uninjured. and preferably undisturbed, during their storage period.

4. Harter, L. L., and Weimer, J. S. A monographic study of sweetpotato diseases and their control. U. S. D. A. Tech. Bul. No. 99, p. [illegible], [illegible].

Sweetpotatoes should be placed in a suitable environment as soon as they are harvested, so that wounds, through which infection occurs, can heal rapidly, and the storage house should be held at a proper storage temperature following the curing period. The conditions suitable for curing and storing sweetpotatoes have been discussed earlier in this bulletin.

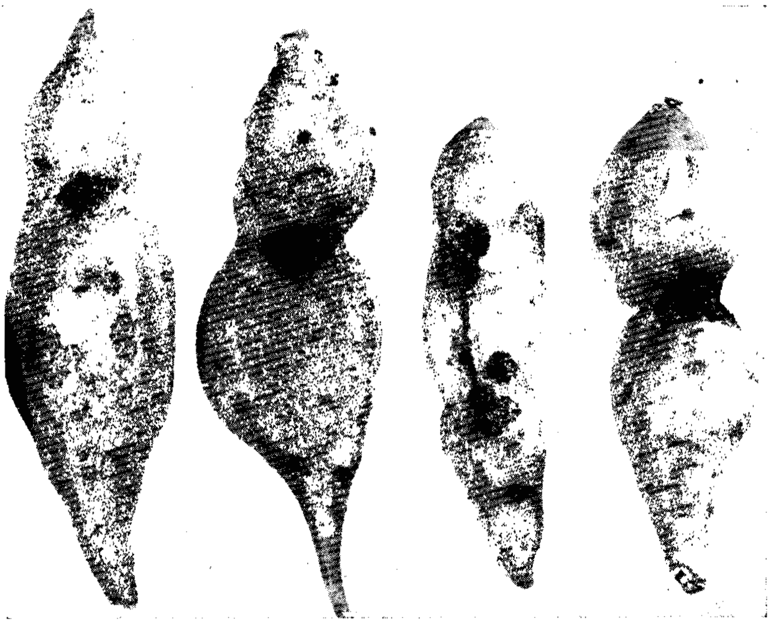

FIG. 10.—Sweetpotatoes affected with soil pox.

When sweetpotatoes become infected while small, constriction results, as shown in the root at the right. Soil-pox infection of more nearly mature potatoes causes pit or scurfy lesions, but little or no constriction.

No varieties of sweetpotatoes are immune from infection with the soft-rot fungus, but varieties vary in susceptibility to this organism. Harter and Weimer[5] state that sweetpotato varieties may be grouped into those that are very susceptible, intermediate, and resistant to this disease. Among the very susceptible varieties are Little Stem Jersey, Gold Skin, and Red Brazil. The moderately susceptible varieties include Yellow Jersey, Porto Rico, and Triumph. Southern Queen is classed as resistant to the soft-rot organism, while Nancy Hall, which was also placed in this class, was later found by Lauritzen to belong rather to the medium susceptible group.

5. *Loc. cit.*

Soil Pox

The soil-pox disease of sweetpotatoes known also as pox and soil rot, is becoming increasingly prevalent in Kansas. The damage produced in Kansas consists chiefly in malformation and pitting of the fleshy root, as shown in figure 10. Infected roots may be so severely injured that they never develop to large size, and market-size roots may be so malformed as to be unsalable The pitted roots have an unsightly appearance which reduces the market value of the pack. Investigations by Adams[6] indicate that the soil-pox disease is caused by a fungus belonging to the genus *Actinomyces.* The causal organism belongs to the same genus of fungi as does the organism that causes the common scab disease of the Irish potato.

Soil-pox infections of the fleshy roots apparently are initiated either when the root is still small, or from invasions of the organism through infected lateral rootlets later in the season. All underground portions of the sweetpotato plant are susceptible to infection. Newly infected areas develop dark-colored, water-soaked lesions of more or less circular or oblong shape. The infections extend into the tissues for only a limited distance, but may be sufficiently deep to injure the water and food-conducting vascular bundles.

Infections that occur when the root is still small may or may not completely girdle it. Death of the lower end of the root results from severe infections, but when all vascular bundles are not killed, as frequently is the case, the lower end of the root continues to grow in length and diameter with the result that a severely constricted sweetpotato develops that appears to be two separate roots attached end to end.

After larger and more nearly mature sweetpotatoes have been infected with the soil-pox disease, a chacteristic pitting symptom appears. Such infections apparently result, from invasions of the organism through infected lateral rootlets. The area actually invaded ceases growth and the pitting symptom is produced because of the continued enlargement of the surrounding uninfected tissues.

Soil pox may cause extremely severe injury to the sweetpotato plant, including rotting off of all or nearly all roots, dwarfing accompanied by a pale-green color of the vines, and in some cases, even death of the plant. The disease has not been noted in such extreme form in Kansas, but affected plants have been observed that contained large numbers of infections, including constrictions and pits on all fleshy roots, blackened rootlets, and numerous lesions on the stems that connect the fleshy root to the crown. Areas in fields have been observed where the plants contained a good set of sweetpotatoes, all of which, however, were culls because of malformation due to soil pox.

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6. Adams, J. F. An Actinomycete the cause of soil pox or pox in sweetpotatoes. Phytopathology, Vol. 19, No. 3, pp. 179-190, 1929.

Losses from soil pox are more serious in dry than in wet seasons. The soil-pox fungus is similar to the Irish potato scab organism in that infections by both are hindered by wet soil conditions.

Applications to the soil of straw or of barnyard manure seemingly favor the increase of the soil-pox organism. In order to prevent the rapid increase of this fungus in the field, organic matter added to fields infested with soil pox should therefore be in the form of green manure crops rather than in the form of straw or barnyard manure.

Very little progress has been made in developing methods for controlling the soil-pox disease. The causal fungus can live over winter in the lesions of infected roots and will remain alive in field soils for many years. Treatment of the planting stock with corrosive sublimate before bedding, as desribed elsewhere in this bulletin, may kill the soil-pox fungus that is on the surface, but, such treatment will probably not be effective for killing the organism that is protected within the lesions. Consequently, diseased roots should be discarded from the planting stock. Prevention of the spread of soil pox to the field must include hotbed sanitation. Hotbed soils should be changed every year with soil obtained from sources that are free from soil pox and other sweetpotato disease-producing organisms, and the frames should be sterilized before the bed is prepared for the new crop.

The difficulty of controlling soil pox centers on the persistence of this organism in the soil when once it has been introduced into the field. The fungus is not dependent, on the sweetpotato plant for continued existence and can remain alive on decaying vegetable matter in the soil for many years. While the organism is not dependent on the presence of the sweetpotato plant for survival, sweetpotatoes are very favorable for its rapid increase and spread in the field. Crop rotation undoubtedly will tend to reduce losses from soil pox, as well as from other sweetpotato diseases.

Scurf

The scurf disease of sweetpotatoes is caused by the fungus *Monilochates infuscans* Hals. This fungus attacks only the underground portions of the sweetpotato plant. The fungus does not penetrate deeply into the tissues of the affected roots, but invades and kills the outermost. layers of cells, thus causing a brownish discoloration of the infected areas. Individual infections vary in size, but remain relatively small. Numerous infections may occur on the same root, and sweetpotatoes may become completely covered with scurf due to the coalescing of numerous invaded areas.

The scurf organism may attack growing sweetpotato plants in the hotbed and in the field. Scurf is especially conspicuous on the roots when they are being taken from the soil at harvest time. Such roots are unattractive and of lower market value, but are otherwise uninjured for cooking purposes. The diseased areas may increase

7. Adams, *loc. cit.*

in size after the affected roots are placed in storage, but new infections of stored roots are rare. When decay occurs it is not caused by the scurf fungus but by secondary organisms that gain entrance through the scurf lesions. Affected roots shrivel during storage and become dry and leathery. The water within such roots is not effectively retained because the protective cork layer of the skin has been destroyed.

The scurf fungus produces spores which may germinate immediately and reproduce the fungus, or which may lie dormant, for a period before germinating. This fungus can also live in field soils from one season to the next. The infection of the new crop of sweetpotatoes, however, occurs chiefly through the organisms that live over winter in the lesions of diseased roots or in hotbed soils. The newly developing sprouts become infected and through them the scurf organism is carried to the field.

For the prevention of the scurf disease, all affected roots should be discarded from the planting stock. The scurf-free roots should be treated with the corrosive sublimate soak treatment so that surface-borne spores may be killed. The scurf organism can also prersist from one season to the next in the hotbed and field soil. Noninfested soil and hotbed frames for bedding should therefore be provided each year, and crop rotations should be used in the field.

When scurf infections develop in the hotbed, Poole[8] recommends dusting the sprouts just, before they are planted with finely ground sulfur. The roots should not be wet when dusted or an injurious amount of sulfur will adhere to them.

Surface Rot

Surface rot of sweetpotatoes is a common storage disease that sometimes causes greater losses than all other storage rots. This disease is caused by *Fusarium oxysporum* Schlecht., a fungus that belongs to the same genus as does the stem-rot organism. The surface-rot, fungus, however. does not produce the stem-rot disease.

Surface-rot lesions are rather circular in outline with regular margins and the affected area is greyish-brown in color. The diseased area is sunken, particularly at the outer margin of the lesion, but the decay extends only a short distance into the tissues of the root. The lesions generally do not become greater than three fourths of an inch in diameter. Sweetpotatoes affected with surface rot become shrunken and dry due to loss of water through the diseased areas. Loss of water may be so great that the root, becomes hard and mummified.

Infections by the surface-rot fungus evidently occur at about digging time or shortly after the sweetpotatoes are placed in storage. It is believed that the fleshy root is invaded through infections that occur on its side rootlets. The disease is most prevalent when the roots are harvested during or following periods of wet weather

8. Poole, R. F. A control for sweetpotato scurf. N. Car. Agri. Exp. Sta. Bul. 274. 1930.

The development of surface-rot lesions on sweetpotato roots is rather slow and six or more weeks of the storage period elapse before conspicuous lesions become apparent.

The color of surface-rot lesions is greyish-brown rather than greenish-black, as is the case with black-rot lesions, and no difficulty should be experienced in distinguishing these two diseases. The pronounced sunken margin of surface-rot lesions does not occur in black rot. Black-rot lesions also have a more irregular outline and they may become considerably larger in area than do surface-rot lesions. The surface-rot disease can be distinguished from injuries due to bruising in that the lesions of surface rot are circular and rather uniform in size, while bruises are indefinite in shape and size.

Sweetpotato varieties differ in susceptibility to the surface-rot fungus. The Jersey varieties, particularly Big Stem Jersey, are among the most susceptible. It was noted by Harter and Weimer[9] that the light-colored varieties are in general rather susceptible to infection, while the dark-colored ones are more resistant. Differences in susceptibility may also occur between plants of the same variety, as was shown by Lauritzen,[10] who isolated from the rather susceptible Little Stem Jersey a strain that is highly resistant to this disease.

Surface rot may be largely prevented by digging the roots when the soil is not wet and on days when their surfaces can dry before they are placed in storage. The disease can be prevented from becoming severe by supplying storage conditions wherein the sweetpotatoes are cured as soon after harvesting as possible. The roots should be placed in a heated storage room on the day they are harvested and a temperature of 85° F. and the proper humidity should be maintained until they are cured.

Foot Rot

The foot-rot disease of sweetpotatoes, caused by the fungus *Plemodomus destruens* Harter, is of importance chiefly as a disease of the growing plant. This fungus attacks both the sprouts in the hotbed and the plants in the field and it causes a decay of the fleshy roots. The roots may become infected either before harvest time or after they are stored. Foot, rot is a widely distributed disease, and in certain sections has at times been very destructive, especially when adequate precautions for its prevention were not practiced. This disease has been found in Kansas, but, so far, has never become serious in this state.

Foot-rot infections of the sweetpotato plant usually originate in the hotbed, although plants may also be attacked in the field. Infected sweetpotatoes used as planting stock are the chief source of sprout infection in the hotbed. Sprouts in the hotbed and plants in the field may also become infected from soil-borne foot-rot fungus, but such infections are generally not very numerous.

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9. Harter, S. S., and Weimer, J. S. The surface rot of sweetpotatoes. Phytopathology, Vol. 9, No. 10, pp. 465-469, 1919.

10. *Loc. cit.*

Sprouts affected with foot rot in the hotbed are stunted and sickly in appearance and those that are more severely diseased die. The invaded tissue becomes nearly black in color and extends to a large portion of the sprout, including the stem to some distance above ground. Fruiting structures (pycnidia) are borne on the affected stems for a short distance above and below the soil line. These fruiting structures appear as very numerous, tiny, cone-shaped, black dots on the surfaces of the rotted stems. Spores of the fungus borne within these structures escape through openings at the peak of cone-shaped pycnidia.

Symptoms of the foot-rot and black-rot diseases on sprouts in the hotbed are rather similar. The black-rot affected stems are generally blacker and the diseased areas are smaller in extent than is the case with stems attacked by foot rot. Black rot does not produce the numerous cone-shaped fruiting structures on affected stems near the soil line and this characteristic is of value in distinguishing between the two diseases.

The first infections of foot rot may occur in the field from the soil-borne fungus, but most of the initial infections develop in the hotbed, from whence the affected sprouts are carried to the field. Plants in the field, as in the hotbed, are affected mainly on their stems near the soil line. The fungus may spread up the vines for some distance and the invasion may progress down the stem into the fleshy roots. Affected stems are frequently girdled and the plant dies. In other cases the diseased plant may live longer and may even produce a crop of sweetpotatoes. Cone-shaped fruiting bodies are borne in great numbers from the infected stem surfaces.

The foot-rot fungus may spread through the underground stem and into the fleshy roots, causing a decay. The roots may be partially or completely decayed at harvest time and such sweetpotatoes should be discarded. Certain roots have only small and inconspicuous infections at harvest time, and these sweetpotatoes may be carried into storage where the infection progresses and a storage rot results. A certain amount of foot-rot decay may develop also from infections through wounds after the roots are dug. Although initial infection of stored sweetpotatoes may occur in storage, such attacks are rare. Foot rot is not one of the important storage diseases of the sweetpotato.

Affected sweetpotatoes in the field or in storage develop a firm, dark-brown-colored decay and numerous fruiting bodies are borne on the surface of the rotted root. Infection in the field usually occurs at the stem ends of the roots. Stored sweetpotatoes also generally decay from the stem ends because the initial invasion usually occurs before harvest from the infected stem of the plant,

Control of the foot-rot disease depends primarily upon preventing infection in the hotbed. Diseased roots should not be bedded and, when possible, seed stocks that contain a large number of foot-rot-affected roots should not be used for planting. Sweetpotatoes to be bedded should be treated with corrosive sublimate solution, as described elsewhere in this bulletin, to kill surface-borne spores of the foot rot and other disease-producing fungi. The hotbed soil and frames also should be free from the fungus. Another preventive measure is to eliminate all infested refuse and dirt from the storage house and to fumigate the storage house before the new crop is harvested.

FIG. 11.—Sweetpotato sprouts affected with Rhizoctonia. The infected areas are relatively small in area and are brown in color

Rhizoctonia

Sweetpotato sprouts in the hotbed are sometimes affected with a decay of the stems due to infections by the fungus *Corticium vagum* B. & C. This fungus, commonly known as Rhizoctonia, has in Kansas occasionally been noted to kill a considerable number of the young sprouts in the hotbed.

The lesions produced by Rhizoctonia on sweetpotato sprouts are dark-colored, sunken, have definite margins, are usually oval or oblong in shape, and are usually not more than one half inch long (Fig. 11.) Only one lesion may occur on a sprout or numerous infections may be present,. These may unite to form a larger affected area that may completely girdle the sprout. Infections occur only when the tissues are young, the plants becoming resistant as the tissues become more mature. The entire sprout may be rotted off when the lesions occur near the growing tip. When infections occur on somewhat older tissues at a short distance below the growing point, more localized lesions result that usually do not kill the sprout. This is particularly true when rootlets are produced above the invaded area. Such sprouts continue to grow when planted in the field.

Rhizoctonia, as a disease of the sweetpotato, is of importance only in the hotbed. The fungus lives from year to year in the soil and is not carried on the sweetpotato through the storage period. When Rhizoctonia has occurred in the hotbed, it is consequently advisable to change the sand or soil before bedding the roots for the following season's planting. The use of fresh hotbed soil each year, sterilization of the frames in the spring, and good growing conditions after the sprouts start growth will prevent infections from this as well as from other soil-borne sweetpotato disease-producing organisms.

Charcoal Rot

Charcoal rot of sweetpotatoes is caused by the fungus *Sclerotium bataticola* Taub. The disease is primarily a storage trouble, but infections of the growing plant may occur. The fungus does not bear spores, but produces black fungous growths known as "sclerotia" by means of which it can survive from season to season and through which it may be transported from place to place.

Sweetpotato-root tissue becomes cinnamon-brown in color when newly attacked by the charcoal-rot fungus, and at this time the infected tissues are spongy in texture. The infected tissues continue to lose moisture and later become reddish-brown in color, and finally, when sclerotia begin forming, become hard, black in color, and charcoal-like in appearance. Spread of the decay within affected roots is very slow. Decaying roots may be divided into zones of distinct color and texture, the outer zone being black and charcoal-like, the middle zone being reddish-brown, and the inner zone adjoining noninfected portions of the root being cinnamon-brown in color and spongy in texture. The diseased root may exhibit no outward appearance of disease for some time following infection, with the exception of a skin color darker than normal. If the skin is broken, the darker skin color is found to be due to the black sclerotial bodies underneath. Completely decayed roots become hard, dry, shrunken, and charcoal-like throughout.

Preventive measures are similar to those described for other storage-rot diseases.

Java Black Rot

Java black rot., a disease of sweetpotato roots in storage, is caused by the fungus *Diplodia tubericola* (E. & E.) Taub. This disease has not been of great importance in Kansas, although it is widely distributed in the United States and causes a large total loss. The Java-black-rot organism rots sweetpotatoes very slowly, six to eight weeks being required from the time infection occurs until the root is completely decayed. The color of affected tissue is brown in the intial stage, but later becomes coal-black. The decayed potato dries up and becomes mummified and hard. Spores are produced in black, cone-shaped fruiting structures called pycnidia, that develop both at the surface of the decayed area and within the decayed tissues. The spores produced within the surface-borne pycnidia may escape soon after they are mature, while those borne within the decayed tissues remain in the pycnidia until the mummied sweetpotato breaks up or disintegrates. Old sweetpotato refuse consequently should be removed from the storage house before a new crop is stored in order that this infective material may be eliminated. Cleaning and fumigating the storage house before the new crop is brought in and supplying good curing and storage conditions are beneficial measures for preventing the Java-black-rot disease.

Dry Rot

The dry-rot disease, caused by the fungus *Diaporthe batatatis* (E. & H.) Harter and Field, causes rotting of stored sweetpotatoes, and infection may occasionally also occur on plants in the hotbed and field. This disease does not cause a very large total loss to the sweetpotato crop. The fungus usually enters the sweetpotatoes at the stem end and from there it spreads slowly through the tissues, requiring from one to two months to invade and destroy the root completely.

Sweetpotatoes affected with dry rot are shrunken and wrinkled and finally become mummified. The flesh of the affected sweetpotatoes is black and the surfaces are covered with numerous small cone-shaped elevations. Spores produced by the fungus are borne in cavities within these minute elevations. The chief difference in the general appearance of sweetpotatoes affected with dry rot and Java black rot is the decided winkling that accompanies dry rot but not Java black rot.

The methods used for preventing the major sweetpotato diseases, such as cleaning and fumigating the storage house, selecting disease-free sweetpotato planting stock, and then treating it and planting in disease-free hotbed soil, are applicable for preventing the dry-rot disease.

Mosaic

Sweetpotatoes are sometimes affected with the mosaic disease, which is caused by a transmissible virus. This disease is not prevalent, but, affected plants have been found in many fields in Kansas, indicating that the disease is widely distributed here. The variety Nancy Hall apparently is especially susceptible to mosaic infection.

The leaves of mosaic-affected plants are small, puckered and malformed. Rather small, variegated patterns of dark green and a lighter yellowish-green occur on the leaves, the variegation in leaf color being rather indistinct. Affected plants have considerably shortened internodes, and this, together with the abnormal leaves causes them to be stunted.

The mosaic virus is present in the leaf, stem and root tissues of the affected plant, and it is transmissible from the mother root to the sprouts. The disease may be transmitted, probably through insects, from diseased to noninfected plants in the field. Presence of the disease cannot be detected on roots in the storage bin and surface applications of fungicidal treatments have no value for controlling the virus. Diseased plants in the field, including their roots. should be destroyed in order that the virus may not be transmitted to the healthy plants, and affected roots should not be included in the following season's planting stock.

Mosaic should not be confused with leaf-color variegation of the sweetpotato in which the yellowish and the dark-green areas of the leaves are larger and may be of a striped pattern, or where a large portion or the entire leaf may be yellowish. Such plants may produce a normal growth instead of being stunted as are mosaic-infected plants. This variegation is due to a physiological or genetic and not to an external cause.

Leaf Diseases

Leaf-spot diseases caused by fungi frequently occur on sweetpotato plants and are most prevalent in Kansas during the late summer and in the fall. As a rule they cause but little damage. Attempts to control them would not be practicable and the expense and time that would be required would not be justified.

SWEETPOTATO INSECTS

The sweetpotato is attacked by a number of different species of insects, but serious injury from this source is not common in Kansas. Among the insects that feed on the aboveground portions are tortoise beetles, sweetpotato flea beetles, and grasshoppers. Underground portions may be attacked by cutworms white grubs and wire worms. The sweetpotato weevil, a very serious insect in the gulf region, has never been reported from Kansas, and even though introduced probably would not be able to survive here.

Two species of tortoise beetles are found in Kansas. The heads of these beetles are concealed under the margin of the thorax, thus giving them a tortoise-like appearance. The Argus tortoise beetle, the larger of the two, is approxinlately one fourth inch long, is reddish-orange in color, and has several black spots on each wing and on the thorax. The two-striped tortoise beetle is smaller and has stripes on the wings. The larvae of these insects are short, flattened grubs with forked tail-like appendages. These insects feed on the sweetpotato leaves and when numerous may cause severe defoliation. They may be controlled by spraying the infested plants with Paris green or with lead arsenate.

The sweetpotato flea beetle is a small, chunky, black insect, one sixteenth inch long with bronzy reflections and reddish-brown legs. It cuts shallow, irregular channels in both surfaces of the leaves, but does not puncture them. The flea beetles appear rather late in the spring and when numerous they may destroy or injure so many of the young plants that replanting is necessary. When replanting because of flea-beetle injury, the plants should be protected by first dipping them in a solution of lead arsenate and lime. These flea beetles leave the sweetpotato near the end of June and migrate especially to bindweed, about which they lay their eggs. The young larvae feed on the bindweed roots, and on reaching maturity the beetles hibernate in rubbish until the following spring, when they may attack the sweetpotato. Sweetpotatoes growing in close proximity to bindweed are most likely to become infested with this flea beetle.

Grasshoppers rarely become serious to the sweetpotato plant, but during severe infestations these insects have been known to destroy young sweetpotnto plantings and even to injure the sprouts in the hotbed. The most effective way to control grasshoppers is to kill them with poisoned bran mash.

Underground portions of the sweetpotato plant, and especially the fleshy root, frequently are injured by both the white grub and by wireworms. White grubs may grow to an inch or more in length. may be about one third inch thick, and have a soft, white body and a rather small, hard, dark-brown head. They are usually found in a curved position. They feed on the roots of various plants and when feeding on the sweetpotato may excavate pit's of various sizes and shapes in the flesh of the root. The root thus becomes unsightly and of lower market value. The injury produced by the grubs may permit entrance of soft rot, black rot, and other decay-producing organisms. The adults of certain species of white grubs are rather large, night-flying beetles commonly known as May beetles or June beetles. In Kansas the common species of white grubs prefer to feed on the roots of grasses and on cereal plants. They are likely to be prevalent in sod soils. Alfalfa, vetch, and other legumes are not attacked by this insect and soils that produced such crops the preceding season are consequently not likely to contain many of them.

Wirworms are the larval form of a number of species of click beetles. The underground portions of many species of plants, including the sweetpotato, are attacked by these slow-moving, yellowish-brown, hard, shiny, slender, worm-like insects. The worms may grow to about one inch in length. They have a hard body covering that is divided crosswise into numerous segments. In feeding on sweetpotatoes, wireworms tunnel into the flesh and the value of the root is thus lowered. Decay-producing organisms frequently gain entrance through these injuries. Wireworms are very difficult to control, but fortunately for the sweetpotato grower, they rarely become serious on this crop.

RODENTS

Considerable damage sometimes occurs to sweetpotatoes in the field from gophers, and in storage from rats and mice. A considerable volume of the roots may be eaten by these rodents and additional losses occur from the decay that frequently develops in the injured roots.

Gophers usually occur locally in fields, and when not controlled they may destroy the yield on a considerable area of ground. Control measures should be taken as soon as signs of their presence is noted. The most effective way to rid the field of gophers is to kill them with poisoned wheat placed in their underground runways. The runways are located by probing with an iron rod, after which the hole may be enlarged with a broom handle, so the bait can bc placed directly in the runway. The hole should then be closed without allowing dirt to fall on and cover the bait. Preparation of poisoned wheat should be made according to the United States Biological Survey formula, directions for which may be obtained from the Kansas Agricultural Experiment Station.

Mice feed on sweetpotato roots both in the field and in storage, but they are rather easily controlled. Should they become serious in the field, they may be poisoned by scattering poisoned wheat on the ground in the infested area. In the storage house they may be poisoned, but preferably should be trapped.

Rats are particularly destructive of stored sweetpotatoes and every effort should be made to prevent their gaining entrance to the storage house. Rats can consume a surprisingly large amount of sweetpotato, but, the amount they eat is only a fraction of the loss they cause. It is well known to experienced sweetpotato growers that soft-rot injury is much more severe where rats are present. The soft-rot organism can enter the wounded sweetpotatoes, not only where the rats have eaten portions of the roots, but also in the tiny punctures made through the skin by the rats' claws when they run over the roots. Soft-rot and other decay-producing organisms may enter through these as well as through larger wounds. The large amount of soft rot that develops when rats are present is due not only to wounding of the roots, but also because the spores of decay-producing fungi are carried about by the rats, so that they actually inoculate the sweetpotatoes.

Sweetpotato-storage houses should be made rat proof *so* these rodents cannot get in. If they do get into the house they should be killed, either by trapping or by poisoning. Trapping rats is usually difficult but, when successful, is preferable to poisoning because they can then be taken out of the house. If poisoning is to be attempted, better success will follow if prebaiting is done in advance to baiting with poison in order that the rats may become accustomed to eating the food that is to be used.

Red squill is recommended for poisoning rats because it is very toxic to this animal, but is not a lethal poison to humans or to farm animals, although it will make them sick if it is eaten. The bait may be prepared by mixing 1 ounce of red squill with water to form a thin paste, then mixing with 1 pound of ground meat or fish, or by mixing 1 ounce of red squill with 1 pound of cereal meal, then adding water or milk and stirring to a mushy consistency.

Barium carbonate is another effective poison for killing rats, but this material will also poison farm animals. It should be placed only where dogs, cats, or other farm animals cannot get to it. In preparing bait with barium carbonate, one part should be well mixed with 6 parts of ground meat, fish or cereal meal and sufficient water supplied so the bait is moist.