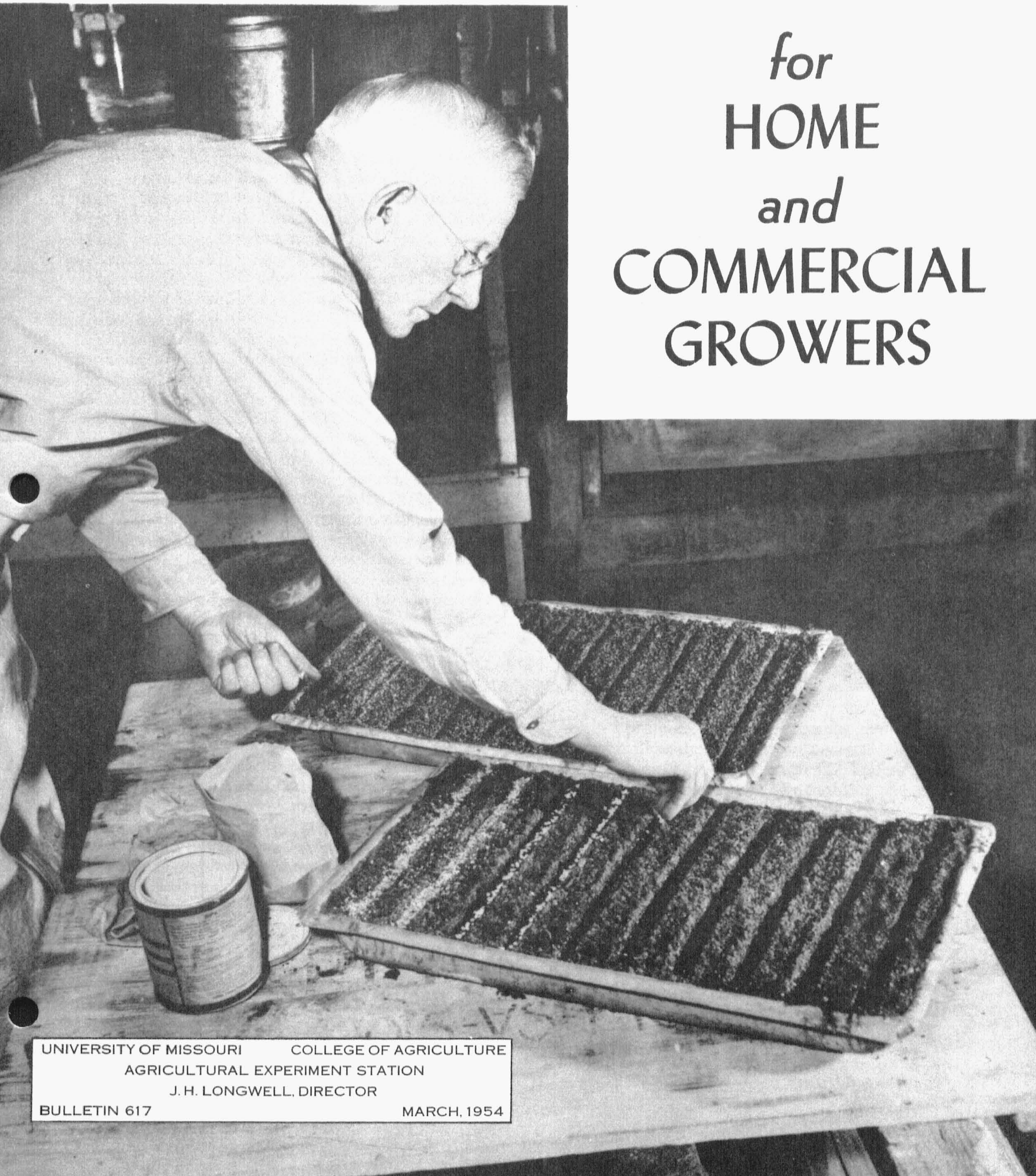
VEGETABLE PLANTS

for HOME *and* COMMERCIAL GROWERS



UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
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Report on Department of Horticulture Research
Project, Purnell 121, Entitled "Truck Crops"

COVER PICTURE

Ernest Roberts, superintendent of horticulture farm operations for the University of Missouri, demonstrates a method of sowing vegetable seeds in flats. Note fungicide for treating seed and vermiculite for covering. July, 1954, marks Mr. Robert's 42nd year of continuous service as an experiment station horticulturist.

Vegetable Plants
for
Home and Commercial Growers

AUBREY D. HIBBARD AND VICTOR N. LAMBETH

Early production of many vegetable crops depends upon the use of transplants. Many commercial vegetables in Missouri are profitable only when an early harvest is possible. Much of the value of a home garden comes from early crops. A number of the cool season vegetables like cabbage and lettuce will not grow and mature satisfactorily during hot weather. Because of the limited favorable season in this climate, it is essential to start with plants.

Success with crops grown from plants cannot be assured unless the plants have been well grown and are free from insects and diseases and in good condition for transplanting at the proper time. Many growers find it more convenient to purchase plants which have been grown locally or shipped in from the southern states than to produce their own plants. When only a few are needed or plant growing interferes seriously with other farm operations, this may be the best practice. But there are many advantages for the gardener who grows his own plants. Vegetable plants usually can be produced at home for less than the cost of commercial plants of similar quality. Suitable plants are ready when needed. If weather conditions prevent planting, they can be held in good condition for some time. Moreover, they can be grown to a larger size than would be economical to ship and handle commercially. Another distinct advantage is being able to grow new and special varieties. Early plants of cucumber, cantaloupe, sweet corn, and lima beans are seldom available commercially but may be grown in plant bands for extra-early production. Certain serious diseases that have been imported through shipped-in plants can be avoided through the use of home-grown plants.

An opportunity exists in most communities to produce plants for sale to other gardeners. Usually there is a shortage of good healthy plants. The man who grows good plants should experience no difficulty in marketing his crop. With a modest investment and good merchandising methods, the growing of vegetable plants can be a profitable enterprise. Vegetable plant production is a good project for the vocational agriculture class or 4-H club. Such projects give the members valuable training and are usually profitable. They are completed in a short period of time and are well suited to group participation. The community benefits directly by having a nearby source of good plants.

CONDITIONS FOR GROWING PLANTS

Since vegetable plants are produced during the early part of the season before conditions become favorable for the growth outside, it is necessary to protect them from unfavorable weather. Most plants will not grow when the air temperature falls below 40 or 45°F. Practically all plants are seriously injured at temperatures below freezing. The cool season crops like cabbage require a night temperature of 50°F while tomatoes and peppers grow very slowly unless the temperature remains above 60°F.

All plant growing structures are designed to secure as much of the required heat as possible from sunlight. It is not economical to build plant beds so tight that no supplementary heat is needed. Artificial heat is supplied to make up for heat lost during cold nights and periods of cloudy weather. When plants are grown in a protected location where the temperature can be controlled, the other factors necessary for plant growth such as light, water, minerals, and air must be supplied. Light is supplied by building the plant bed in a sunny location, sloping the cover toward the south and covering with a transparent material like glass. Since the plant bed is enclosed, water and air must be furnished when needed.

Plant food is provided by a fertile soil, supplemented with fertilizers as the plants develop. The successful plant grower learns to supply the things necessary for plant growth in the correct amounts. He watches constantly both the plants and the weather. Each kind of vegetable plant must be handled somewhat differently and no two seasons are exactly alike. The type of structure in which the plants are grown and the details of culture described in this bulletin can be varied as long as the requirements for plant growth are met.

Plant Growing Beds

The simplest kind of plant growing bed consists of a plot of specially prepared soil in a protected location. A space on the south side of a building can be made into a plant bed where seed can be sown two to three weeks earlier than in the open field. A windbreak along the north and west sides of a range of frames protects the beds from strong, cold winds and makes heating more economical. All plant growing structures, regardless of how heated, depend on the sun for most of their warmth. By selecting a southern exposure it is possible to take the maximum advantage of heat from the sun. A site with some slope, preferably toward the south, is highly desirable. Good drainage is very important around plant beds.

Cold Frames

An unheated enclosure for a plant bed is called a cold frame. The frame can be built of lumber, concrete, bricks, or other materials and should be as nearly air-tight and as well insulated as possible. The most durable frames are of concrete or masonry construction, but these materials have very poor insulating qualities. Beds made from them should be banked with soil to the top of the masonry construction or otherwise insulated. Concrete blocks made with insulating aggregates are available. The same aggregate material is available for mixing concrete with improved insulating qualities. A frame of 2-inch lumber has the same insulating value as 2 feet of ordinary concrete or 10 inches of hollow tile. Lumber used in frame construction should be treated with a good wood preservative which is not harmful to growing plants. Several kinds are available from building supply dealers.

Frames usually are built 6 to 12 feet in width to accommodate one or two rows of standard hotbed sash. This is also a convenient width when other kinds of covering are used. The bed may be as long as desired, but most growers find a length of 75 feet most practical. The lowest, or south side, should allow at least 10 inches of head room for the plants. The north side, for a bed one sash in width, is built from 6 inches to 1 foot higher. This permits water to drain off and takes full advantage of the available sunlight. Beds 12 feet in width are built highest in the center with the sash sloping in opposite directions. A plan for a small cold frame is shown in Figure 1.

Covering the Frames

The ideal covering for a plant bed admits the maximum amount of sunlight, seals the bed against culd outside air, and prevents loss of heat by radiation during the night. An insulating cover frequently is the only cover used on cold frames late in the season. Such covers are put in place at sunset and removed in the morning. Wide boards of 1-inch lumber are used frequently for such temporary coverings. Additional protection can be secured by covering these boards with straw or other types of loose, dry material during periods of severe cold. These materials are easier to handle when woven into pads. A more elaborate pad is a quilt of burlap stuffed with some type of insulating material. Burlap and cotton pads are available commercially. Pads can be used effectively in preventing heat loss when used over glass filled sash.

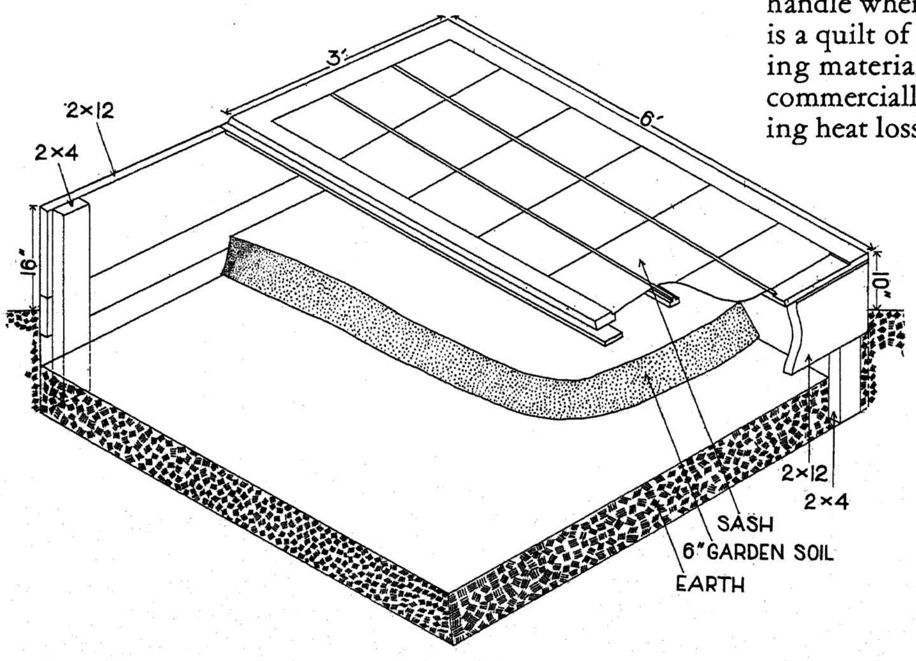

Figure 1—This suggested plan for building a cold frame may be enlarged to accommodate more sash.

Inexpensive bed coverings which afford considerable protection and admit some light are sometimes constructed from muslin or similar white cloth. The cloth covers can be tacked to frames but usually are placed on rollers so they can be rolled towards the top of the frame when not in use. The cloth can be treated with a waterproofing compound to keep out excessive rain water.

Glass Substitutes

The chief objection to cloth covers for plant beds is that they shade the plants too much. The most satisfactory covering for plant beds is glass filled sash. Glass substitutes made from plastic materials have been on the market for a number of years. The plastic film is on a wire or cloth backing to give mechanical strength. In use, the plastic cover is fastened to a frame and handled like regular sash. In addition to being less expensive than glass, it is light in weight and easy to handle. While excellent plants can be grown under such coverings, the best are only 50 percent to 75 percent as efficient in transmitting light as glass and beds under them will run about 10° cooler when the same amount of heat is applied. Because of the extra heat required and the fact that their useful life is three years or less, it is doubtful if there is much long range economy in using these substitutes for glass.

Glass Sash

Any type of glass filled sash may be used for covering the plant bed, but the most practical ones are those built especially for this purpose. Most sashes come in a standard size of 6 by 3 feet and are glazed with three or four rows of glass. While glass sashes are more expensive than other types of plant bed coverings, they will last for 20 years or more if properly stored and painted. The sashes may be built by a good carpenter but most growers find it is more economical to secure them from a reliable manufacturer. Considerable saving results from ordering the sashes unglazed and unpainted.

New sash should be painted with a good grade of white paint before glazing. In glazing, the putty is first placed in the glass grooves and the glass laid on the putty. Start at the lower side and work toward the top, lapping each pane about ¼ inch over the one below. Since the panes are held in place with glazing brads there is no need for any putty on the upper side of the glass. The same method should be followed in replacing broken glass. After glazing, the sashes are given a second coat of paint on both sides. If at the end of each season the sashes are repaired, given another coat of paint, and stored in a dry place, they will last for many years.

Heating the Hot Beds

Vegetable plants started earlier than three weeks before the average date of the last killing frost will require more heat for growth than sunlight supplies. Plants can be grown for a small home garden in a single sash bed heated through a basement window. Larger hotbeds are heated by fermenting horse manure, hot flue gases from fires, hot water, and electricity. The small-scale plant grower will find electric heating most satisfactory for his purposes. Commercial growers may find flues or hot water desirable under certain conditions.

Manure Heated Hotbeds

Fermenting horse manure has been used for a long time as a source of heat for hotbeds. The bed for manure heating is built exactly like the cold frame, except that a pit 18 to 30 inches deep is dug to hold the manure. Adequate pit drainage is essential. Once the manure becomes water logged, fermentation stops and no heat is produced. In some locations it may be desirable to pile the manure on top of the ground and

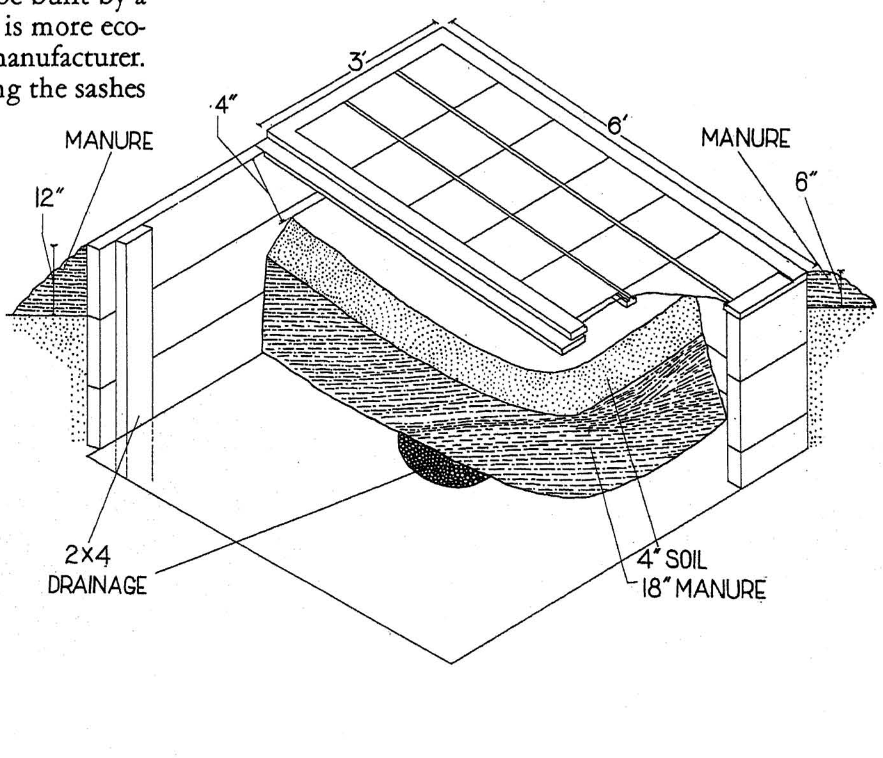

Figure 2—Plan for a manure heated hot bed.

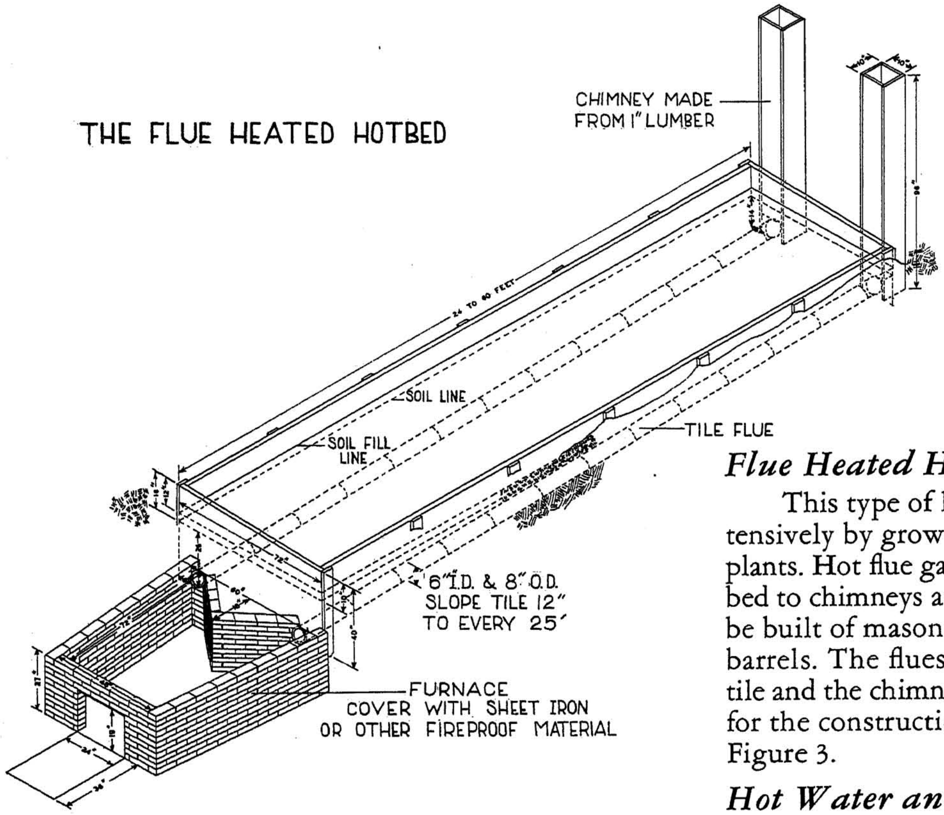

Figure 3—A general plan for a flue heated hot bed. The design may be changed to fit needs of the plant grower.

build the frame on top of the manure. Fresh horse or mule manure containing about one-third straw is most satisfactory. Other livestock manures are less desirable and should contain a larger portion of straw. Any manure that cannot be made to heat in the manure pile should not be placed in hotbeds.

The manure is collected about 10 days before the hotbed is started. It is first piled in a compact heap and left until fermentation begins, and then re-piled. As heating begins the second time, the manure is placed evenly in the bed and carefully tamped—especially along the edges and in the corners. A 4- to 6-inch layer of fertile soil is placed over the manure. The bed is covered and allowed to heat for several days. The soil temperature may rise to 125°F. When it falls to 85°, seed may be planted. It is advisable to use a soil thermometer after seeding. The temperature is regulated by opening or closing the covers. The manure heated bed gradually becomes cooler as the season advances.

Flue Heated Hotbeds

This type of heating formerly was used quite extensively by growers of sweet potato and late tomato plants. Hot flue gasses from a furnace are led under the bed to chimneys at the opposite end. The furnace may be built of masonry, sheet iron, or even discarded oil barrels. The flues are made of 6- or 8-inch drainage tile and the chimney of furnace pipe or lumber. A plan for the construction of a flue heated bed is shown in Figure 3.

Hot Water and Steam Heat

Greenhouse owners and others who have a source of steam or hotwater heat available frequently pipe this heat into their range of frames. It is a most satisfactory type of heat where the cost of installation can be justified. Such a system should be installed by someone familiar with this type of heating.

Sash Houses

A small greenhouse is very convenient for growing plants but it is doubtful if the cost of construction is justified when the structure is to be used for this purpose alone.A small house can be built much more economically from standard hotbed sash. A plan for a small sash house is shown in Figure 4. The sash

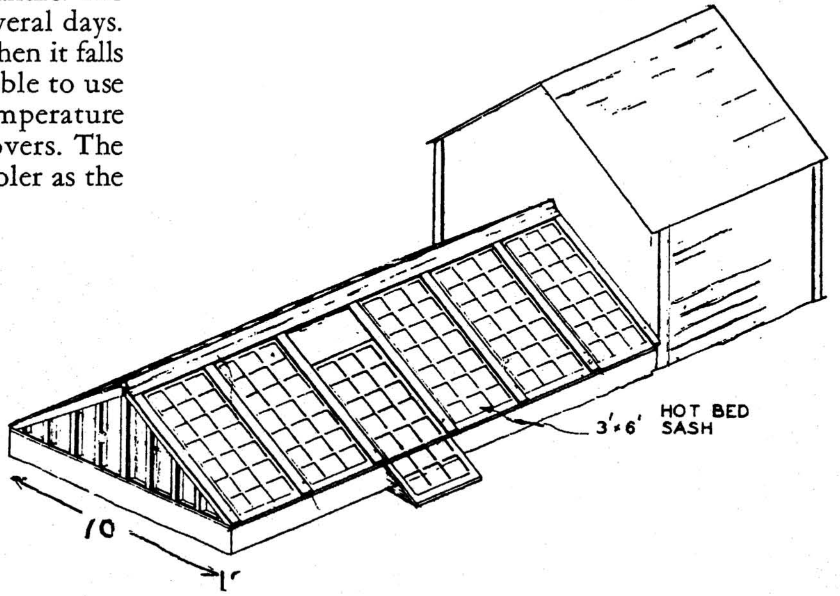

Figure 4—A suggested plan for a small sash house to start vegetable plants.

house is essentially a double width hotbed of sufficient height to permit a walk down the center so that work may be done under cover.

The sash house may be heated with electricity, which may be the most economical method when the house is used for a short season and electrical rates are favorable. Most houses of this type, however, are heated with stoves, space heaters, or hot water. The latter is the most satisfactory but more expensive to install.

Electric Hot Beds

Electricity is rapidly replacing other sources of heat for hot beds. Manure of suitable quality has become virtually unobtainable in many locations while dependable electrical current is generally available at economical rates. Electrical heating equipment is installed easily and can be made automatic. Electrical heating reputedly is less expensive in first cost and operation than hot water or steam systems unless they are used for other heating throughout the season. It also compares favorably with manure, when the latter is purchased and the labor for handling is considered. Most vegetable plants can be grown to the same size in 10 days less time in an electric bed than in one heated with manure. The amount of current required to heat a hot bed depends upon the months when operated, the temperature maintained, the construction of the frame and insulating qualities of the covering, and the skill used in management.

From 1 to 2 kilowatt hours of current are required per sash per day to heat the average hot bed. During the winter months as much as 3 KWH may be used per day, while in April and May less than 1 KWH will be needed. Data collected at the Missouri station show that about 60 KWH of current will be required per sash for the entire plant growing season. The desirable heating load for each sash is 200 watts, which is sufficient to maintain the air temperature within the bed 40° above the outside air temperature.

While electrical heat may be applied to the bed in several ways, the most practical method appears to be with soil heating cable in which the heating element is protected by a lead or plastic sheath. The heating cable is sold in lengths which will supply a certain amount of heat when connected to a 110 volt service. A cable which supplies about 400 watts in 60 or more feet of length should be chosen. This amount will be sufficient for a bed two sashes long. When more sashes are to be heated extra lengths of the cable are used. Beds up to 10 sashes long can be heated through the main switch of a residence service. When larger beds are to be heated, a special service switch with larger fuse capacity or 220 volt service will be required. A representative of the power company should be contacted for advice on safe and efficient electrical installation requirements.

The heating cable is laid directly on the ground. Insulation under the cable has been proven unnecessary. It is important that the turns of the cable be the same distance apart throughout. The spacing between the cable strands (Figure 5) should be 3 to 5 inches for the plastic covered type and about 7 inches for the lead covered cable. At the outer edges it should come to within 3 inches of the frame. It is a good idea to place a screen of ½-inch mesh hardware cloth over the cable to protect it from mechanical injury. A layer of 4 to 6 inches of soil is placed over the screen and the bed is complete (see Figure 5). For crops which are seeded directly in the frame, the cable may be laid on top of the soil. Flats with growing plants may be placed directly on the cable without a layer of soil between. Another use of the cable in plant growing is

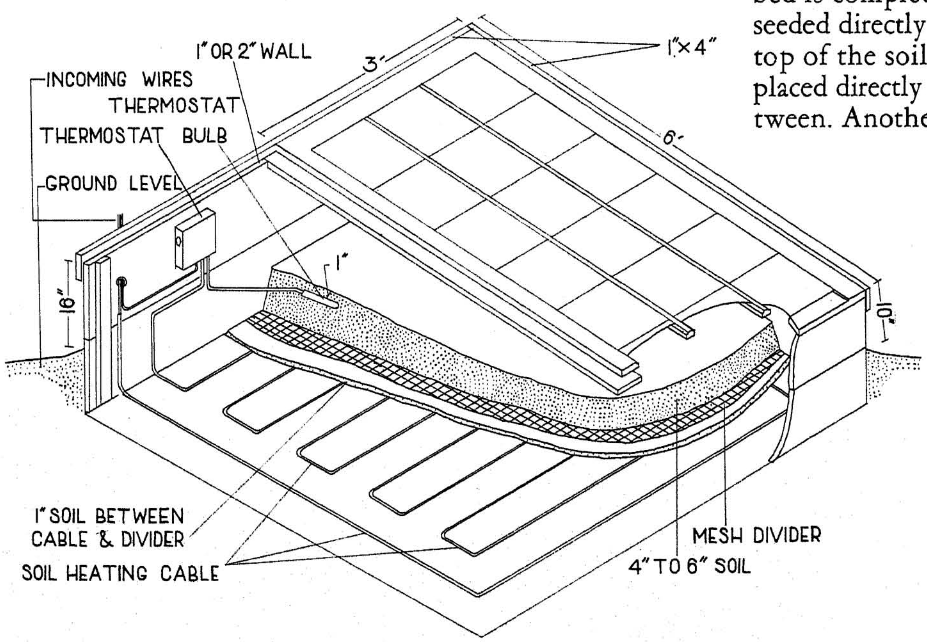

Figure 5—Plan for installing soil heating cable in a hot bed.

to run a single strand around the inside of the frame at the soil line to be used only when frost protection is needed late in the season.

A feature of electrical heating which appeals to the small grower is that the current can be switched on automatically with a soil thermostat. Most thermostats on the market designed for this purpose will handle up to four units of heating cable or a bed of eight sash. Additional thermostats are required for larger beds. Commercial growers, who can watch their beds constantly, may prefer to switch the current manually. Beds can be wired so that only a part of the cables are turned on at a time to provide two or more levels of heat.

Hot beds heated with electricity require less watering and ventilation than those using manure. Current can be saved by opening the frames only during warm sunny days. Spreading pads or mats over the sash at night will result in a saving of 20 to 45 percent in power consumption.

BED SPACE REQUIRED

Enough vegetable and flower plants for the average family garden can be grown under one or two standard 3- by 6-foot hot bed sashes. When plants are grown commercially for field setting or sale, the amount of space required depends not only upon the number of plants needed but also upon the method of growing the plants. By direct seeding into the frame it is possible to produce a maximum of 1,000 to 1,500 plants per sash, depending upon the kind of vegetable. Most growers pull less than 700 usable plants per sash.

The seeds frequently are seeded thickly in flats and the seedlings transplanted into other flats or frames when the first true leaf appears. When these seedlings are spaced 2 by 2 inches apart, a maximum of 643 plants can be grown per sash, but if they are transplanted into standard flats measuring 13 by 18 inches and holding 54 plants each, only 540 plants can be grown under each sash. Melons and other crops which are planted in bands or pots will require much more space. With 3-inch bands, 288 plants can be grown per sash and only 162 when 4-inch bands are used. An allowance for plant loss of about 10 percent is reasonable when the operator is experienced and uses the most efficient growing methods. This allowance should be increased to 20 percent when only the first quality plants are to be used. The amount of bed space required for a particular crop can be determined by adding this allowance to the number of plants required per acre and dividing by the number which can be grown per sash.

Canning tomatoes, main crop cabbage, and onions are seeded directly into the frames and are not transplanted before going to the field. Plants for early market crops frequently are started in flats and transplanted into other flats or frames. Only when extra large and very early plants are needed is it desirable to transplant a second time into bands or pots. Remember that transplanting does not improve the quality of plants and the operation is expensive because of the labor required. The advantage lies only in the conservation of space and heat. The fact should not be overlooked that, by transplanting, a succession of plant crops can be grown in the same structure. In an efficient operation the plant growing frames and houses will be fully occupied from the first of February until the month of June.

Using Flats for Growing Plants

The types and sizes of plant growing structures needed will depend upon the kinds of plants produced, as well as the methods of production. Plants for extensive acreages like sweet potatoes and processing tomatoes, must be grown at a cost which is competitive with shipped-in field-grown plants, regardless of the fact that locally grown plants may be more desirable. Plants for such crops usually are produced by seeding directly into the frames and growing to field setting size without transplanting. Plants for early fresh market crops or for sale frequently are grown by methods which require one or more transplanting operations before they are large enough to go to the field. This method of plant production requires much more hand labor and the plants may take as much as two weeks additional time to reach transplanting size. When a plant is transplanted it receives a shock and may require several days for recovery. The advantages of transplanting are that the grower does not have to furnish heat to all of his frames when the plants are small and when a sash house is available, the work may be done in the comfort of a heated room.

In the transplanting method, seeds are sown thickly in a flat of sterilized soil or soil substitute. The seedlings are grown until the first true leaf appears, then transplanted to another flat in which the spacing between plants is 1½ to 4 inches depending upon the kind of crop and the final size desired. More than 1,000 seedlings can be started in a 12 by 18 inch flat, while a similar number in the frames will occupy from one to six sash areas. The flats of plants are grown first in a hotbed and later transferred to a cold frame before going to the field.

Flats used for plant growing should be of a size that is convenient to handle and will fit the frames without wasting space. Ten flats with overall dimensions of 13 by 18 inches will fit in a sash. Smaller flats are sometimes used as a marketing package. A soil depth of 2 to 4 inches is adequate. Flat shooks, ready cut from durable wood like cypress, cedar, or redwood, and ready for nailing, can be purchased from manufacturers of greenhouse supplies. Less durable woods are satisfactory when treated with a nontoxic preservative such as pentachlorophenol. Creosote and coal tars should be avoided. Inexpensive flats can be made at home from discarded crating. They will last for several years when treated with a wood preservative.

Flats also are used to hold individual plant growing containers. These are made in the form of square bands from wood veneer or fiber board. They may be purchased in various sizes. The use of plant bands eliminates most of the shock from transplanting. Seed may be sown directly into the bands. Most bands decay rapidly and do not have to be removed when the plants are set out. As decomposition starts, the decay organisms may rob the plant of available soil nitrogen. This trouble can be prevented by feeding extra nitrogen or using treated bands which contain extra amounts of plant food. Bands treated to resist decay are unsatisfactory since they have to be removed when the plant is set out.

Several devices can be built that save considerable time when doing the transplanting. A guide to mark the rows when seeding and a spotting board to locate the holes in transplanting are time savers. These tools, together with flats, are shown in Figures 6 and 7.

SOIL, SOIL MIXTURES AND TREATMENT

Soil used for starting plants should possess a loose, granular structure to favor the emergence of seedlings, to provide good root aeration, and to permit rapid drainage of excess water. In addition to good texture, it should provide an adequate and well-balanced supply of nutrients and be free from plant disease organisms. A fertile sandy loam, well supplied with organic matter and sterilized to free it of disease organisms, will fulfill most of these requirements. Since such soils are rarely found in cultivated fields, most growers will need to prepare a soil mixture.

A satisfactory mixture can be prepared by mixing equal parts by volume of good loam soil, coarse sand and well-rotted manure, leaf mold, or compost. Fresh, strawy manure or unrotted leaves should not be used as a source of organic matter without composting because the utilization of available nitrogen by decaying organisms often results in nitrogen starvation of the plants.

Except where fertilized compost is used in the soil mixture, some commercial fertilizer generally will be required. Commercial fertilizer should be applied according to soil test recommendations, since unknown deficiencies of some elements may exist. Furthermore, indiscriminate use of commercial fertilizer on fertile soil mixtures or those made from unleached manure can result in toxic amounts of soluble salts which reduce plant growth by injury to the roots and in severe cases kill the plants (Figure 8). The following table of recommended nutrient levels for soils and soil mixtures, based upon the Missouri method of testing, will serve as a satisfactory guide for county extension agents and other soil testing personnel making fertilizer recommendations: phosphorus (P_2O_5) 350-400 pounds per acre; exchangeable potassium 400-600 pounds per acre; exchangeable magnesium 350-400 pounds per acre; exchangeable calcium 4000-5000 pounds per acre. The organic matter content should be at least 4 percent and the pH by soil test approximately 6.5.

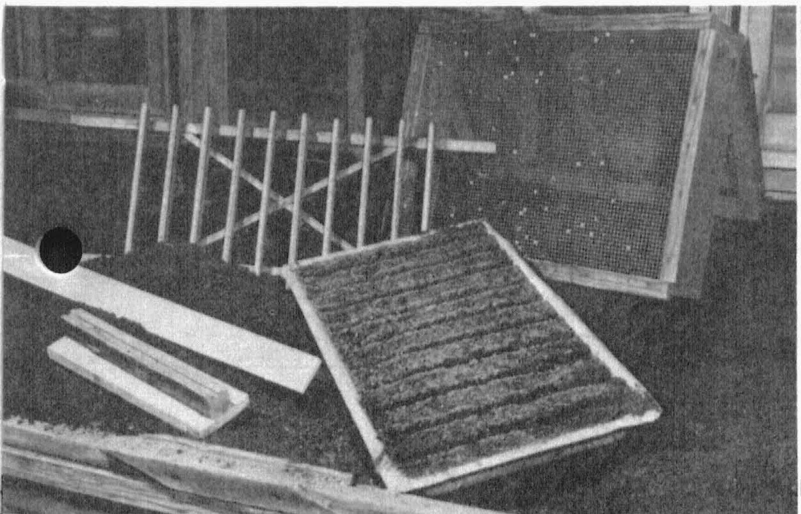

Figure 6—Soil screen, row marker, leveling board and packing float speed the work when sowing seeds in flats.

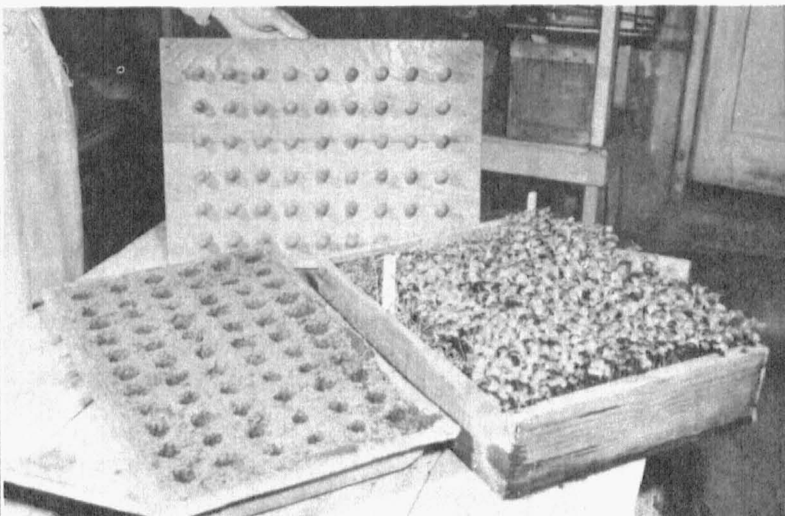

Figure 7—A spotting board saves time in locating evenly spaced holes for transplanting seedlings in flats or beds.

Figure 8--Tomato plants stunted by excessive salts in the soil resulting from continued applications of manure and commercial fertilizers.

The conversion from amount of fertilizer per acre (as recommended from soil test results) to amount per bushel of soil or amount per standard hot-bed sash (3′ by 6′) can be determined readily by referring to Table 1.

TABLE 1 -- EQUIVALENT FERTILIZER RATES; FIELD AND PLANT-BED APPLICATIONS

If number of pounds of a given analysis fertilizer (or lime) required per acre is:	The number of level tablespoons required per bushel of soil is approximately:	The number of ounces required per standard sash is approximately:
200	½	1.5
400	1	3.0
600	1½	4.5
800	2	6.0
1000	2½	7.5
1200	3	9.0
1400	3½	10.5
1600	4	12.0
1800	4½	13.5
2000	5	15.0

The commercial fertilizers should be applied before seeding and mixed evenly throughout the soil.

SOLUBLE SALTS INJURY COMMON IN PLANT BEDS

A recent survey of the fertility of plant bed soils in the state showed a majority contained an excessive concentration of soluble fertilizer salts—that is, in excess of the soil's exchange capacity. Upon saturating the soil's clay and organic matter fraction, the salts increase rapidly in the soil water and may accumulate to a point where water is withdrawn from the plant root. This "physiological drought" results in stunting and, in the more severe cases, to death of the plants (Figure 8). Growers frequently refer to this condition as "root burning."

The problem is a serious one in plant beds because of a natural tendency to over-fertilize small areas. The small soil volume involved and the likelihood of confusing the plant symptoms with nutrient deficiencies, damping-off, and other diseases further complicate the problem. Obviously, the "salt" problem is a distinct one requiring specific corrective measures.

By proper use and evaluation of the soil test, the accumulation of excessive concentrations of soluble salts as a result of over-fertilization and overliming can be avoided. In addition to the soil test, measuring the electrical conductivity (or resistance) of the soil solution to the passage of an electrical current will give a rapid and sufficiently reliable measure of the condition of a soil with respect to "Salting." In experiment station work the commercially available Sol-U-Bridge instrument is used. For practical work and routine testing, a 1:2 soil-water extract is made and the conductivity reading taken after 30 minutes.

By correlating conductivity readings (Sol-U-Bridge) and seedling growth, a general tolerance level has been established beyond which growth is seriously affected. Table 2. While this tolerance is somewhat

TABLE 2 -- TYPICAL CORRELATIONS BETWEEN CONDUCTIVITY OF SOIL SOLUTION, NITRATE CONCENTRATION AND GROWTH OF SEEDLING PLANTS
(Summary of hundreds of observations)

Vegetable Seedling	Conductivity of 1:2 Soil-Water Extract	Active Nitrate (Spurway) (ppm)	Notes on Growth of Plants
Tomato	34×10^{-5} MHOS	15	Satisfactory; light green color.
Tomato	90×10^{-5} MHOS	25	Satisfactory; slightly darker green foliage.
Tomato	180×10^{-5} MHOS	75	Some stunting. Stems spindly; stems and leaves bluish-green.
Tomato	400×10^{-5} MHOS	125	Plants very stunted. Leaves and stems very bluish-green. Root damaged.
Lettuce	65×10^{-5} MHOS	20	Very good
Lettuce	90×10^{-5} MHOS	25	Growth satisfactory
Lettuce	140×10^{-5} MHOS	60	Plants stunted, chlorotic.
Lettuce	170×10^{-5} MHOS	70	Very stunted. Limited root system at surface.
Lettuce	260×10^{-5} MHOS	95	Roots plasmolyzed. Plants died after transplanting.

variable with the crop and the kinds of salts in solution, in most cases a conductivity approaching 180 x 10^{-5} MHOS (reciprocal ohms) should be regarded as indicative of approaching trouble. Correlations between conductivity reading and nitrate concentration (ppm) show high nitrates to be a major contributor to the soluble salts concentrations in most plant beds.

Avoiding the acculumation of toxic concentrations by the judicious use of manures and commercial fertilizers is more satisfactory than any corrective measure. Where a bed has good underdrainage, however, it is frequently possible to leach out many of the salts. In cases where nitrates only are troublesome, working a carbonaceous (woody) material such as hay, straw, or crushed corn cobs into the soil is often beneficial. In severe cases of salting, replacement of the "salted" soil with good field soil of favorable fertility appears advisable.

SOIL SUBSTITUTES FOR STARTING SEEDLINGS

Vermiculite

Vermiculite, an insulating material available at most hardware and farm stores, is one of the better soil substitutes for starting vegetable seedlings. While contributing little in the way of nutrients, it permits good root aeration, provides excellent water relations, and is free of the common disease organisms generally troublesome in plant-bed soils. It is particularly good for germinating seeds in flats for later transplanting to individual containers since the seeds usually germinate more promptly and show a better germination percentage than when grown in soil. Vermiculite-grown seedlings, as a rule, have a better root system and are much easier to transplant without damaging the roots. Vermiculite-grown seedlings that are to be transplanted into individual containers should be transplanted soon after the appearance of the first true leaves or else fed with a complete liquid fertilizer. By weekly feedings and careful thinning to provide adequate growing space, plants can be grown in the vermiculite to a size suitable for transplanting to the field.

Spagnum Moss

Shredded spagnum moss is another good soil substitute for starting seedlings. Generally, good seedlings can be grown in spagnum without the constant vigilance and exacting attention to details necessary for success with soils. As with vermiculite, there is usually less trouble with "damping-off" and less danger of over-watering, and the plants can be grown to field transplanting size by watering occasionally with nutrient solutions. Spagnum has been found superior to soil for growing plants to be shipped because of its lighter weight and ability to withstand rough treatment without damage to the root system.

Spagnum may be used in hot beds or cold frames as well as in any of the conventional plant containers, provided there is adequate drainage. The moss may be used alone or it may be used as a covering (approximately 1 inch thick) over soil-sand or sand-peat mixtures.

Before using, spagnum moss should be shredded to a consistency which will pack solidly. Small quantities can be shredded by rubbing the moss through a wire screen having three meshes to the inch. The moss is then moistened slightly, placed in the flat or other container, and the surface firmed. Next, it is watered thoroughly and allowed to stand for a few minutes before seeding.

Nutrient Solutions for Growing Plants

Plants grown in sand, gravel, or vermiculite culture are most conveniently fertilized with a water-soluble fertilizer. Moreover, plants started or transplanted into soil or soil mixtures frequently benefit from the application of nutrient solutions. A formulation widely used in soilless culture that can be mixed conveniently is given in Table 3.

TABLE 3 -- NUTRIENT SOLUTION FORMULA

Chemical salt	Grade of salt	Approximate amount for 25 gals. of water: in ounces	in level tablespoons
Ammonium phosphate (Monobasic)	Technical grade	½	2
Potassium nitrate	Fertilizer grade	2½	5*
Calcium nitrate	Fertilizer grade	2½	6
Magnesium sulphate (Epsom salts)	Technical grade	1½	4

*powdered salt

Where these salts are not available, a satisfactory substitute can be made by dissolving 5 or 6 teaspoons of a low analysis fertilizer, such as 5-10-5, or about 3 teaspoons of a high analysis garden fertilizer, such as 8-24-8 or 4-24-12, in a gallon of water. Generally, sufficient trace elements will be available in the soil or as impurities in the fertilizer that their addition need not be of concern in growing young seedlings.

Many commercial liquid-starter fertilizers or water soluble powdered mixtures are now available for supplementary feeding. Because of the great variation in their analyses, they should be used according to the distributor's recommendations. Unless otherwise recommended, fertilizer solutions should not be applied to the foliage and any solution spilled on the leaves should be washed off immediately.

TIMING THE SEEDING

When to Plant

Beginning plant growers often make the mistake of starting their plants too early. The plants become too large by transplanting time unless they are given extra space in the plant bed. Growth can be slowed down by withholding water and lowering the temperature. Such treatments can be overdone. Badly stunted plants fail to grow rapidly when set in the field thus destroying most of the advantage of using early plants. Best results are secured when the plants are growing vigorously when ready for transplanting. They should be hardened just enough to withstand the outside weather conditions.

A longer time must be allowed to grow plants that are transplanted one or more times before moving to the field than to grow them directly from seed in the plant bed.

A calendar that may be followed in growing plants is given in Table 4. The frames used for cabbage and related crops can be used later in the season for growing sweet potatoes or celery.

The calendar also gives the approximate amount of seed to produce 1,000 plants, as well as the amount to sow per sash. It is assumed that the seed will be planted in rows spaced 3 to 4 inches apart. The approximate plant bed area required to produce plants for a given acreage can be calculated from the last three columns in Table 4.

TABLE 4 -- PLANT GROWING CALENDAR FOR MISSOURI

Kind	Date to Seed in Hotbed	Seeding to First Trans-planting Days	Seeding to Field setting Days**	Growing Temper-ature* °F.	Amount of Seeds for 1,000 Plants	Amount to Sow per Sash	Plants to set one acre
Onion Bermuda	Middle Jan.	-----	60-80	50-60	2/3 oz.	1 oz.	60,000
Cabbage	1st. Feb.	10-14	30-45	50-65	4/5 oz.	1 oz.	10,000
Cauliflower	1st. Feb.	10-14	30-45	50-65	1/4 oz.	1/2 oz.	10,000
Broccoli Sprouting	1st. Feb.	10-14	30-45	50-65	2/5 oz.	1/2 oz.	7,000
Brussels Sprouts	1st. Feb.	10-14	30-45	50-65	2/5 oz.	1/2 oz.	7,000
Lettuce	1st. Feb.	14-21	40-60	50-65	1/5 oz.	1/2 oz.	40,000
Egg plant	1st. Week Mar.	21-28	50-70	65-75	2/3 oz.	1 oz.	3,600
Pepper	1st. Week Mar.	21-28	40-60	65-75	2/3 oz.	1 oz.	9,000
Tomato	Middle March	10-14	35-50	60-75	2/3 oz.	3/4 oz.	3,000
Sweet Potato	1st. Week April	-----	40-50	70-85	1/3 bu.	1 bu.	7,000
Celery	Middle April	28-35	60-70	60-75	1/8 oz.	1/2 oz.	30,000

*The temperatures indicate the minimum for night and average for daytime. Extra ventilation should be given when the temperature in the bed goes above the higher temperature.
**Days indicate time required to grow plants from seeding without transplanting under favorable conditions.

PREVENTING DISEASES

Virtually all of the diseases occurring in the plant bed and many of those appearing later in the field, can be prevented by following a few precautionary measures before seeding and by careful attention to plant bed management. Since some of these diseases are soil borne, others internally or externally seed-borne, and still others transmitted by insects or other mechanical means, a variety of control practices are necessary to insure good disease-free plants. These practices include sterilization of the soil (or use of sterile soil substitutes); seed treatment for seed-borne diseases and pre-emergence "damping-off;" fungicide sprays for post-emergence damping-off; careful plant handling; proper insect control in the plant bed; and proper control of temperature, watering, and ventilation of the plant bed.

Control of "Damping-off"

"Damping-off" of plant bed seedlings can be caused by several kinds of soil-inhabiting fungi. Two stages of the disease are common—pre-emergence damping-off, in which the fungi attack and kill the germinating seed before it reaches the soil surface, and the post-emergence stage, in which the fungus attacks the tender stem at or near the soil surface, causing the plants to wilt, fall over, and die. These damping-off organisms develop rapidly in wet soils and with high temperature and may destroy a plant bed in a few hours.

In addition to damping-off, many of the most troublesome diseases of vegetable crops, such as bacterial and fusarium wilts, bacterial canker, black rot, and black leg of cabbage and related plants, are soil-borne and generally start in infected plant bed soil. These soil-borne diseases are best controlled by thorough soil-sterilization.

Heat Sterilization

Thorough heat sterilization of plant bed soil affords effective control of all soil-borne diseases, nematodes and weeds. Where a large volume of soil is required, an electrical or steam-heated sterilization box (Figure 9) or cabinet is very desirable. Regardless of the heat source, a temperature of at least 180°F should be maintained for an hour or longer throughout the entire soil mass. For best results check the temperature with an accurate thermometer placed in the "coolest" location. Only in this way can thorough and effective sterilization be assured. A sufficient amount of soil for a few flats can be sterilized in an ordinary kitchen oven. Since heat sterilization is most effective on a moist soil, it may be desirable to moisten very dry soil before sterilization.

Where soil is sterilized by steam, a period of at least 10 days should lapse before seeding to allow time for beneficial soil organisms to become re-established. This also gives time for re-aeration of the soil and for the transformation of harmful chemicals.

Recently, a portable flash-flame soil pasteurizer has been developed, tested, and proven satisfactory for the sterilization of plant bed soil. With this pasteurizer, the heat is applied directly to the soil with a flame. Because of the short exposure time and low final soil temperatures obtained, the organic matter is not destroyed in the process. The treatment kills most weed seeds as well as most "damping-off" fungi. The capacity of one unit is reported to be approximately 2 cu. yds. of soil per hour when soil conditions are favorable.

Disinfection and Fumigation

From the practical standpoint, the use of chemicals for disease control in plant bed soil appears to be limited to situations where sterilization by heat is not possible. The chemical action of most fungicides and fumigants usually is specific, being effective for a relatively few organisms and ineffective against many others.

Formaldehyde treatment—In sterilizing small volumes of soil by the formaldehyde method, dilute 2½ tablespoons of commercial formaldehyde (40 percent solution) with sufficient water to thoroughly dampen a bushel of soil. Mix thoroughly and cover for 24 hours. Work the soil and allow to aerate for 4 or 5 days before seeding.

For soil in plant beds, dilute 1 gallon of formaldehyde with 50 gallons of water and apply to the seed bed with a sprinkling can at the rate of 2 quarts of the diluted solution per square foot of soil surface. After

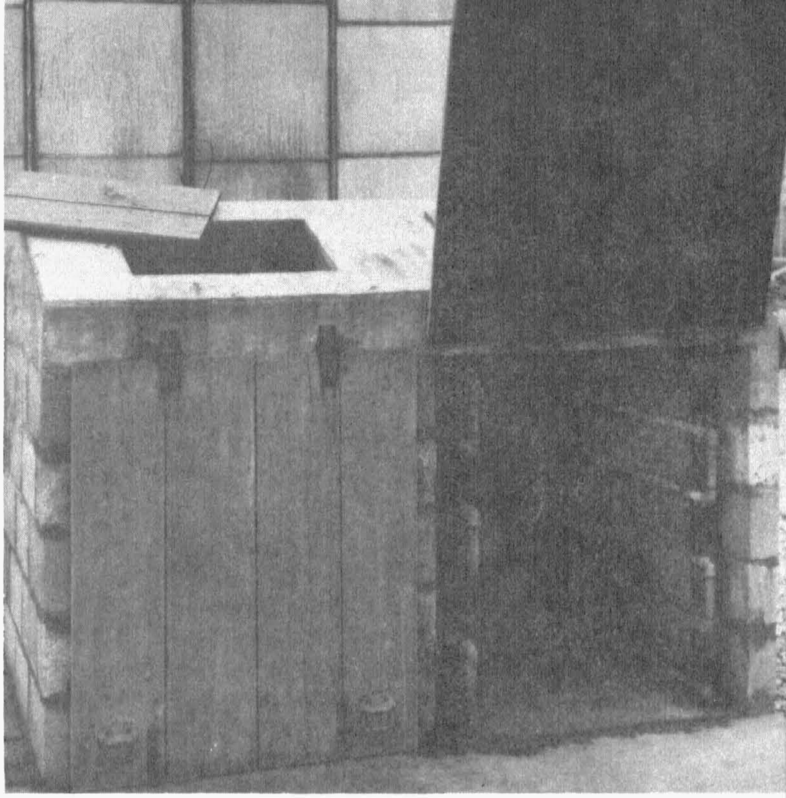

Figure 9.—A steam-heated soil sterilizer built with concrete blocks and standard pipe fittings. Note opening for filling and door for soil removal.

application of the liquid, turn the soil and cover with canvas, plastic sheeting, or sisalkraft paper to confine the fumes. Remove the covering after 24 hours and spade the soil. In addition, the soil, frames, flats, and any tools which will come in contact with the soil also should be treated.

Caution: *Do not seed or transplant in the treated soil for at least 10 days following the formaldehyde treatment.*

Soil Fumigants

In the past few years, several chemical soil fumigants for the control of soil-borne plant bed diseases, weeds, and soil-borne insects have become available for commercial use. Most of these materials are very reliable and have proven valuable for specific uses where other means of sterilization are not feasible. It should be realized, however, that because of their specific chemical action, their practial value is likely to be limited to a relatively few soil-borne diseases and insect pests. Some of these materials require special application equipment and a gas-proof seal over the soil. The best coverings for this purpose are made of plastic or plastic-coated materials. Because of these limitations and differences in concentration of active ingredients, the manufaturers directions should be followed as closely as possible; otherwise, the results are likely to be disappointing.

Seed Treatment

In addition to being seeded in clean or sterilized soil, vegetable seed should be treated to free it of bacteria and fungi carried on and within the seed coat. Effective control in some cases requires soaking the seed in hot water or corrosive sublimate, in addition to treatment with a seed protecting fungicide. The seed protectants also give some protection against damping-off organisms in the soil.

Successful hot water treatment, without serious reduction in germination, is dependent upon accurate control of temperature. Use a good thermometer in checking the temperature and keep the water stirred constantly. Generally it is better to gradually increase the temperature to the desired point by small additions of hotter water than to attempt to do so by heating the container directly. Because of the danger of overheating, it is usually desirable to purchase seed which already has been given this treatment. Specific suggestions for treating vegetable seeds for the control of seed-borne diseases are given in Table 5.

Sowing Seeds

The soil in which the seed is sown should be well prepared by mixing and screening. When flats are used, the soil is carefully tamped into the flat to within one-half inch of the top. Shallow furrows 2 inches apart and from ¼ to ½ inch in depth are marked to receive the seeds. Seed is sown at the rate of 8 to 10 seeds per inch when the seedlings are to be transplanted. Seedlings for plants that are to be grown to maturity in a cold frame are planted in rows 3 to 6 inches apart at the rate of 2 to 4 seeds per inch of row.

Most vegetable seeds are covered to a depth of ¼ to ½ inch. Soil is commonly used for covering the seed. Where trouble from damping-off is anticipated, cover with fine sand or any other material which dries off quickly. Dried spaghnum moss that has been rubbed through a fine screen, and vermiculite, have proven to be excellent covering materials for seeds in flats, In addition to aiding in the control of damping-off, these materials apparently stimulate faster and stronger germination. The photograph in Figure 10 shows

TABLE 5 -- SEED TREATMENT FOR CONTROL OF SEED-BORNE DISEASES

Vegetable	Treatments	*Disease controlled
Cabbage	Soak 25 minutes in hot water at 122° F. Dry and dust with Semesan, ½ level teaspoon to 1 pound of seed.	Black-leg Leaf-spots Black-rot
Broccoli Cauliflower Turnip Kohlrabi	Soak 15 minutes in hot water at 122° F. Dry and dust with Semesan, ½ level teaspoon to 1 pound of seed.	Black-leg Leaf-spots Black-rot
Tomato	Soak in hot water (122° F.) for 25 minutes, cool seed, and soak 5 minutes in New Improved Ceresan ¾ level teaspoon in one gallon of water or 1 ounce in 9 gallons of water. Drain and dry without washing.	Anthracnose Septoria leaf spot Bacterial canker Bacterial fruit spot "Damping-off"
Peppers	Soak 5 minutes in mercuric chloride (corrosive sublimate) one 8-grain tablet in 3 pints of water. Rinse in running water for 15 minutes and dry thoroughly. Dust dry seed with ½ level teaspoon of Semesan or 1 level teaspoon of cuprous oxide to 1 pound of seed.	Damping-off Seed-rot
Eggplant	Soak in hot water at 122° F. for 30 minutes. Cool, dry and dust with ½ level teaspoon of Semesan or 2/3 level teaspoon Arasan to 1 pound of seed.	Phomopsis blight Damping-off Seed-rot
Cucumber Watermelon Muskmelon Pumpkin Squash	Soak 5 minutes in corrosive sublimate, one 8-grain tablet in 1 pint water or 1 ounce in 7½ gallons, for 15 minutes. Use one gallon for each pound of seed. Dry and dust with Arasan using 1 level teaspoon per pound of seed.	Anthracnose Angular leaf spot Scab
Onions	Dust with Arasan or Semesan or Phygon 1 level teaspoon per pound of seed.	Damping-off Smut

Note: In addition to these fungicides there are other chemical products which may be equally effective but are not as generally available.

Cautions: Because of the highly poisonous nature of corrosive sublimate and most of these fungicides, they should be kept out of reach of children and animals and any remaining solutions carefully disposed of. Follow precautions given on the container label. Solutions of corrosive sublimate are very corrosive to metals and should, therefore, be used only in glass, stone, wood or other non-metal containers.

a typical flat of tomato seedlings in which half of the flat was covered with a sifted sphagnum moss while the other half was covered with fine sand. Similar results were secured with all of the common vegetables and several kinds of flowers.

Transplanting Seedlings

The only advantage in transplanting is the saving in bed space. Transplanting injures the plant in proportion to the amount of root destroyed. All plants suffer a setback in growth when transplanted. The earlier in the life of the plant that the transplanting operation is performed, the less severe will be the shock. Seedlings are ready to transplant when the third leaf (first true leaf) appears. They are set in flats or frames with a spacing from 1½ to 3 inches both ways. The seedling is lifted with as much of the root system intact as possible and placed in holes previously spotted in the flat. The soil is pressed firmly around the base of the plant. Plants are set from ½ to 1 inch deeper in the flat than they grew in the seedling row. After transplanting is finished, the soil should be settled around the plants by watering. The same procedure is followed in setting plants into a hotbed or cold frame.

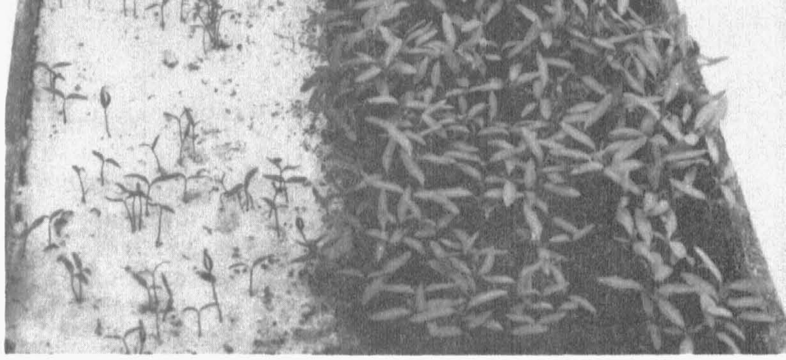

Figure 10.—Covering seed with spagnum moss promotes rapid germination. The halves of this flat received identical treatment except for covering the seed.

Plants that are to be grown to maturity in a frame should be thinned as soon as the stand can be determined. The plants should stand from ½ to 1 inch apart in the row after thinning. One of the aims of the plant grower is to produce as many plants as possible in the bed space available. Overcrowding in the plant bed is one factor responsible for the poor plants seen on the market. Plants cost more to produce when given sufficient growing space but are worth much more to the grower.

FRAME MANAGEMENT

Temperature

The proper temperature is of greatest importance in growing plants. The frames have not been properly built unless the desired temperatures can be maintained. It is neither desirable nor practical to keep the temperature constant. Under natural conditions considerable variation occurs between night and daytime temperatures. Cabbage, lettuce, onions, and other cool season crops make the most satisfactory growth with daytime temperatures around 60 to 65°F, but the night temperatures may be 10 degrees cooler. The temperature under glass on a bright day can go high enough to seriously injure the plants. The warm season crops like tomato, pepper, and eggplant do best with a temperature from 70 to 75°F during the day and 60°F at night. As the time for field setting approaches, the temperature should be lowered gradually until the plants are growing without artificial heat or protection in the frames. The temperature for cool season crops, especially cabbage and celery, should not remain below 50°F for an extended period of time as this may induce premature seeding or bolting.

Watering

Young plants require very little water. It is a common mistake to keep the plant bed too wet. If the bed is well watered immediately after planting, it should require no more water until the seedling comes up. The soil should be wet to a depth of several inches when water is applied. This is much better than frequent light sprinklings. The soil should not be watered again until the surface begins to dry. Since the soil in most frames will dry unevenly, the parts that become dry first should receive the heaviest watering. As the season advances and the plants increase in size, more frequent watering will be required.

Watering should be done during the mornings of bright days. This will permit the excess water to evaporate. Moisture standing on the soil and plants greatly aggravates the trouble from damping-off diseases.

Ventilation

Ventilation of the plant bed is necessary to regulate the temperature and remove excess moisture. On bright days ventilation is required to keep the temperature from going too high. Even on cold days enough ventilation should be given to prevent moisture from condensing on the underside of the glass. Where glass sashes are used, this is done by sliding the sash downward or by propping it up on the side away from the wind. Direct drafts are to be avoided. The bed should always be ventilated after watering.

Post-Emergence Damping-off

Although it is sometimes possible to check damping-off in the plant bed after an infection appears, the spray method should not be considered a satisfactory substitute for the preventive control methods.

Young vegetable seedlings (except lettuce and melons) can be sprayed with Semesan solution at the rate of 1½ quarts for 10 square feet on medium or heavy soils or 1 quart for 10 square feet on sandy soils. A compressed air sprayer is satisfactory for the application.

For the more severe cases, two or three applications may be necessary to arrest development. In such cases, allow several days to lapse between treatments and provide maximum ventilation

The Semesan solution is made by stirring 1 level tablespoon of Semesan in 1 gallon of water or 1 pound of Semesan in 50 gallons of water.

Hardening

The conditioning of plants to withstand field conditions is referred to as hardening. Plants of the cabbage family can be hardened to a point where they can withstand hard freezes. Tomato and pepper plants cannot be hardened enough to make them frost resistant. There is danger of carrying the process too far, causing the plant to become permanently stunted. Hardening can be accomplished by any practice which brings about a slowing down of plant growth. A short supply of plant food, low temperatures, and a lack of moisture seem to be equally effective in decreasing the rate of growth. The most convenient way for the plant grower to harden plants is to withhold water.

Plants are adjusted to outside conditions by starting about 10 days before the time for setting. More ventilation is given until the beds can be left uncovered during the night. The plants are watered just enough to keep them from wilting during this period. Attempts to harden plants by withholding plant food probably are not advisable. In fact, feeding of soluble fertilizer four or five days before plants are to be transplanted is a desirable practice. Recent experiments have shown that when the fertilizer contains a large proportion of potash, the hardening process is accelerated.

Starter Solutions

Plants that are well supplied with plant food seem to withstand the shock of resetting and grow better than those that are starved.

Most soils and soil mixtures used for plant growing will provide adequate nitrogen for the early growth of the plants. Later in their development, however, supplementary applications of nitrogen usually are required. This is indicated by yellowing of the leaves and stunting of growth. Considerable experience in judging the amount of nitrogen required in supplemental applications is needed for different plants growing under variable soil, light and temperature conditions. Cabbage, broccoli and cauliflower, for example, require more nitrogen than most other vegetable plants. Nitrogen should be withheld from tomato plants near transplanting time in most instances to prevent them from becoming too succulent.

Plants which begin to yellow slightly, or otherwise indicate a need for nitrogen, can be watered with a solution made by dissolving 1 ounce of ammonium nitrate in 7 gallons of water or fed in the dry form, using about 3 ounces of ammonium nitrate per 100 square feet of bed space. Where the liquid method is used, several successive waterings at weekly intervals may be needed in some cases.

FIELD SETTING DATES

The chief purpose in using vegetable plants is to secure an earlier harvest than can be accomplished by seeding directly in the field. The time when vegetable plants can be set out depends on the likelihood of their being injured by freezing temperatures and on the prevailing minimum night temperatures. For example, tomatoes will not be injured unless frost occurs but will make very slow growth and set no fruit unless the night temperature remains above 60°F. Recent studies at this station show that regardless of how early tomato plants are set in the field, there will be few ripe fruit until the last week of June. The earliest tomato harvest dates, secured by some of the best growers who use every known practice which will help secure an early crop, are shown in Table 6.

The early harvest date is apparently more dependent upon the temperatures which prevail during the months of May and June than upon the date of actual field setting.

Most vegetable growers realize that the risk of having tender vegetable plants killed by frost is too great when such plants are set out near the average date of the last killing frost in the spring. On the

TABLE 6 -- EARLIEST TOMATO HARVEST DATES SECURED BY EXPERIENCED COMMERCIAL GROWERS

Year	Kansas City	St. Louis	Diamond (Near Neosho)
1946	June 29	July 10	No Record
1947	July 12	Crop Flooded	June 28
1948	July 3	July 6	June 28
1949	June 25	July 1	June 22
1950	June 30	July 1	June 22

other hand if they delay setting until the date of the latest killing frost recorded for their locality, it will be too late to secure early production. It is necessary to take some risk with frost to get an early crop. Cabbage and related cool season vegetable plants when properly hardened will withstand frosts and light freezes but may be killed by a severe freeze. The amount of risk which will be taken when setting plants on a certain date can be figured from the long weather records which are available for most localities in the State. The dates for selected localities after which there is risk of a severe freeze occurring one year out of ten are shown in Table 7.

TABLE 7 -- SAFE DATES FOR SETTING VEGETABLE PLANTS WITH A FROST RISK OF ONE YEAR OUT OF TEN

Locality	Severe Freeze 24° F. or lower*	Moderate Freeze 28° F. or lower	Light Freeze 32° F. or lower**
St. Louis	April 5	April 16	April 26
Kansas City	April 6	April 17	April 27
St. Joseph	April 9	April 18	May 1
Neosho	April 10	April 18	May 2
Springfield	April 9	April 19	May 3
Columbia	April 9	April 22	May 4

*Earliest safe dates to set hardy crops in the open.
**Tender crops like tomato, pepper, eggplant, and sweet potato make very little growth when set before these dates, even when frosts do not occur.

GROWING TOMATO PLANTS IN COLD FRAMES

Good tomato plants for field setting an be grown in the southern part of the state in ordinary cold fames. Plants ready for setting on May 1, can be grown from seed sown between March 20 and 25. Such plants will produce the first ripe fruit around July 4, if growing conditions are favorable. Excellent plants have been produced by the cold frame method in southwestern Missouri (Table 8). The plants have been equal if not superior to those shipped in. The cost of growing is no greater than the amount paid for plants grown elsewhere.

TABLE 8 -- FIELD SETTING AND FIRST HARVEST DATES FOR COLD FRAME GROWN RUTGERS TOMATO PLANTS AT MONETT, MISSOURI

Year	Seed Sown in frames	Plants set in field	First Commercial Picking
1938	March 20	May 6	July 21
1939	March 21	May 3	July 19
1940	March 19	May 3	July 17
1941	March 21	May 5	July 14
1942	March 20	May 9	July 28

The frames used at the University of Missouri Monett Experimental Field were covered with glass sash. Muslin or canvas covered frames in protected locations would probably produce plants as early.

Additional frost protection to that furnished by the sash is necessary once or twice during the season. This can be provided by covering with loose straw, boards, or hotbed mats. Local weather forecasts should be followed so that covers can be put on in time to hold enough heat in the beds to prevent damage.

The soil should be made as favorable for plant growth as possible. A well-drained loam soil taken from an old fence row or from the woods is satisfactory. A 6-inch layer of the soil is placed in the cold frame and covered with 2 or 3 inches of rotted manure. A complete commercial fertilizer of 5-10-5 or similar analysis is added at the rate of ¾ pound for each sash area or 18 square feet. Soil, manure, and fertilizer are mixed thoroughly by spading several times. The prepared soil is then leveled and prepared for seeding. The treated seed is sown in drills running

Figure 11—Tomato plants for the canning crop growing in a cold frame.

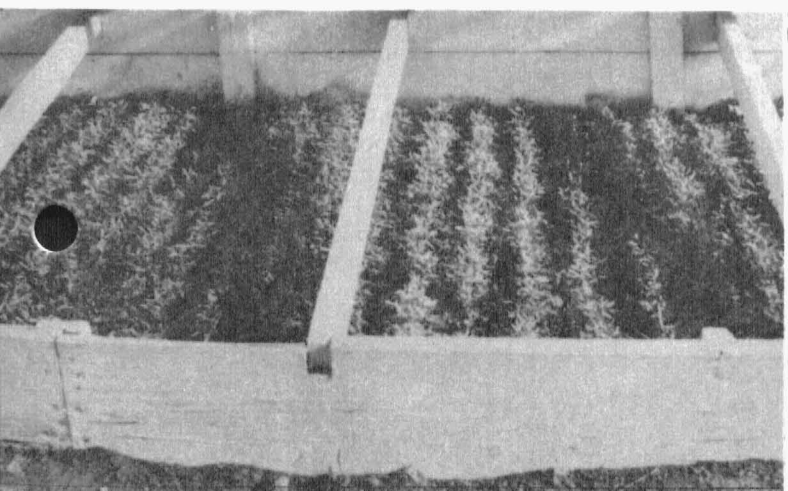

Figure 12—Tomato plants with large root systems are desirable. To avoid stripping off, plants should be lifted from the bed—not pulled.

the narrow way of the bed and spaced four inches apart.

After planting, the beds are watered and the covers put in place. When the first true leaf appears, the plants are thinned to stand about 1 inch apart in the rows. An outbreak of "damping-off" may be controlled by watering with a solution of an organic fungicide such as Semesan or others specifically recommended for this purpose. The beds must be kept free from weeds and the plants watered when the soil becomes dry. More and more ventilation is given until the covers can be left off at night as the time for setting approaches. When the plants show signs of starvation as indicated by a yellowing of lower leaves, they should receive a feeding of fertilizer. The yellowing of tomato leaves sometimes is caused by an infection of early blight. This can be identified by the dead areas on leaves and stems. It can be controlled by spraying the plants at intervals of 10 days with any good fungicide.

Weather conditions may prevent setting the plants when they are ready. Experimental work has shown that it is not desirable to hold back the growth of tomato plants. The stunted plants grow slowly after they are reset and the first cluster may fail to set properly. The best way to handle over-grown tomato plants, apparently is to cut off the tops just above the second leaf. Plants treated in this way do better than those that have been allowed to become long and spindling or retarded in growth.

GROWING SWEET POTATO PLANTS

Sweet potato plants are grown somewhat differently from other vegetable plants. Some bottom heat is desirable even though the plants may be produced without covers on the beds. Most growers provide muslin covers for emergency protection against frost. Flue heated hotbeds are used in many localities for growing sweet potato plants.

Only good seedstock should be used for bedding. Many serious diseases can be carried from the plant bed which would be detrimental to the resulting crop. The grower can protect himself by using only certified seed. This seed comes from fields that have been inspected by representatives of the State certifying agencies. The potatoes are re-inspected in storage. When the crop is found to be relatively free from serious diseases and true to variety, the grower is issued a certificate which permits him to sell the particular lot as certified seed.

A grower may have his plants certified by bedding certified seed, observing certain prescribed measures for disinfecting the frames and treating the seed, and having the plants inspected. Application for certification is made to the State Commissioner of Agriculture at Jefferson City, Mo., well in advance of bedding time. A small fee is charged for this inspection service.

Soil is not desirable for use in bedding sweet potato seed. A 3- to 4-inch layer of clean sand is placed in the bottom of the bed. The seedstock is placed on this sand, leaving a space from ½ to 1 inch between the potatoes. After bedding, the potatoes are covered to a depth of 1 inch with sand and watered. The sand and water should be at the temperature of the bed since chilling will bring about a delay in sprouting and may cause the potatoes to decay.

The temperature of the plant bed may be as high as 85°F when the roots are bedded. It should then be allowed to drop gradually and should not go below 70°F. A temperature between 70° and 80° is most satisfactory for the greater part of the plant forcing period. Since the temperature should not be allowed to go above 85°F., the sash of the hotbed must be elevated during sunny days to keep the temperature down. The bedding material should be examined throughout its depth every few days to determine the need for water. The bedding material should not become too dry for good growth or become wet enough to encourage disease. When the first sprouts push through the sand, an additional layer of 2 or 3 inches of sand can be placed on the bed to encourage the production of a stronger root system. Partially decayed sawdust may also be used for this last cover. Plants should be exposed to outside temperatures both day and night, to harden them off, for about a week before pulling time.

If insects, particularly aphids, become troublesome spray or dust with Lindane. To make the spray, add Lindane (25 percent wettable powder) to water at the rate of 1 pound per 100 gallons or 1 level teaspoon per gallon.

Under this system of plant production, about six weeks are required to obtain a good supply of plants of most varieties. Therefore, where plants are to be transplanted to the field around May 15, the roots should be bedded around April 1. Sweet potato slips are ready for pulling upon reaching a length of 6 to 8 inches.

Generally, plants smaller than 6 inches in length result in poor stands and yields, and plants longer than 8 to 10 inches are difficult to transplant. In case the plants are in danger of becoming too rangy, they can be held back to some extent by withholding water and heat from the plant bed.

It is best to water the plant bed lightly, to loosen the slips, the day before the plants are to be pulled. They should be pulled and handled carefully to avoid injury to the slips and to the bedded roots. Before setting in the field, the plants should be sorted to eliminate all small weak plants. Immediately after pulling, the roots of the slips should be placed in wet sawdust or peat moss and covered with wet burlap to keep them from drying. Dipping the roots in a fungicide solution, such as was used in treating the seed stock before bedding, is of some value in preventing the spread of any disease which may occur in the plant bed. It must be realized, however, that this treatment supplements rather than replaces the other sanitation practices, which are—using disease-free seed stock, fungicide treatment before bedding, and growing in a clean soil.

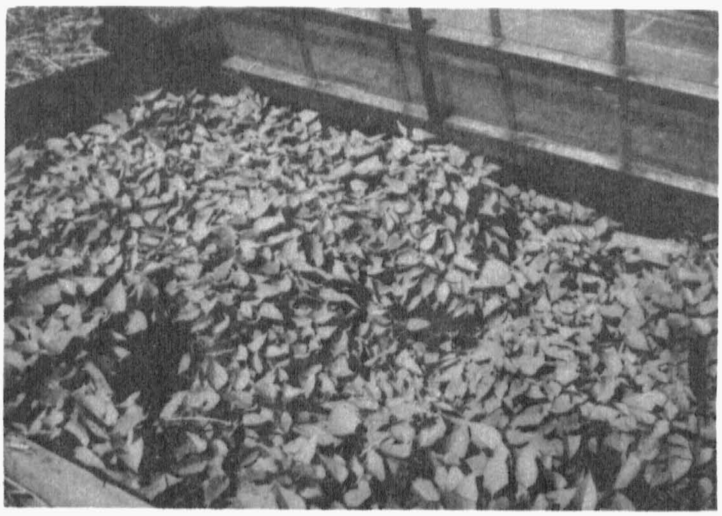

Figure 13—These sweet potato plants have made sufficient growth and should be pulled. Two more crops of plants can be obtained from a single bedding of roots.