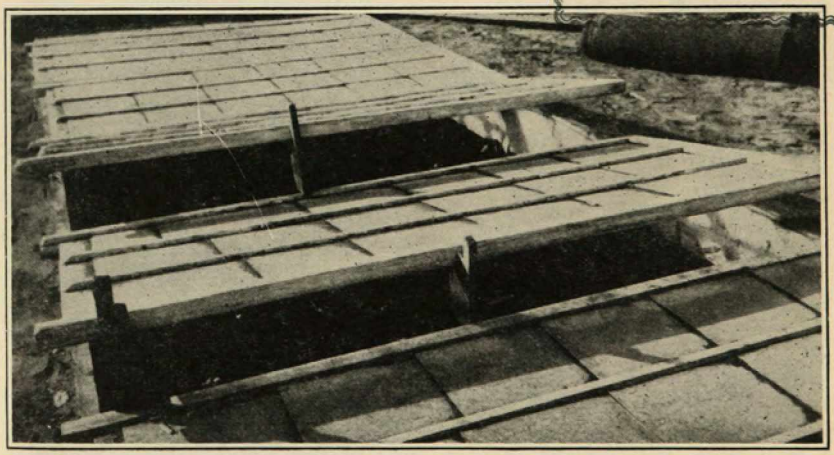
Starting Vegetable Plants

A. M. BINKLEY



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Starting Vegetable Plants In Colorado*

A. M. BINKLEY

THE short growing season in many parts of Colorado makes it necessary for the vegetable grower to use special plant-growing structures to produce some of his crops most efficiently. Many long-season vegetable crops, such as cauliflower, cabbage, celery, eggplant, early head lettuce, peppers, and tomatoes must be started by growing plants in hotbeds and coldframes for later transplanting to the field. Such crops as lettuce, radishes, beans, beets, cucumbers, and carrots can be grown to maturity in such structures early in the season, before they can be grown out of doors. Hotbeds and coldframes are useful for wintering-over special seed crops and half-hardy plants and perennials.

The main purposes of starting plants in plant-growing structures are: (1) to increase the length of the growing season; (2) to produce seasonable crops earlier; (3) to protect young plants from unfavorable spring weather and disease and insect injury; (4) to produce crops that require a long season to mature; (5) to increase yields per acre; and (6) to produce more crops on the same land in one season. Plant growing structures are good investments for vegetable growers; the cost is small and the grower increases his chances of producing more profitable crops.

If well-grown disease-free plants are available, it is undoubtedly better for the home gardener to buy rather than raise his own plants. A medium-sized plant that is stocky, has a good root system and good color, and is free from insect and disease injury is the type to purchase for transplanting. Better-grown plants cost more because they have been given more space and care, but it will pay to avoid plants that are tall, spindly, of poor color, and that have weak root systems.

Plant Houses

For large-scale plant growing, it is better to use sashhouses, small greenhouses, or houses especially built for plant growing. Temperatures and humidities are easier to control and facilities for work are more convenient.

Small sashhouses can be constructed by joining hotbed sash back to back on a 1-inch by 6-inch ridge board. Then a 24-inch pathway is dug down the center to permit the operator to work. Heat can be provided by stoves, although air-circulating heaters are more satisfactory.

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*Revision of Colorado Agricultural Experiment Station Bulletin 328.

There are many types of small greenhouses used in growing plants, and the manufacturers of greenhouses and greenhouse equipment will furnish detailed plans upon request.

Hotbeds

A hotbed is a plot of earth enclosed by a frame, covered with glass, and provided with some sort of artificial heat. The most common and most easily constructed type of hotbed is that in which fermenting stable manure is used as a source of heat. Hotbeds are

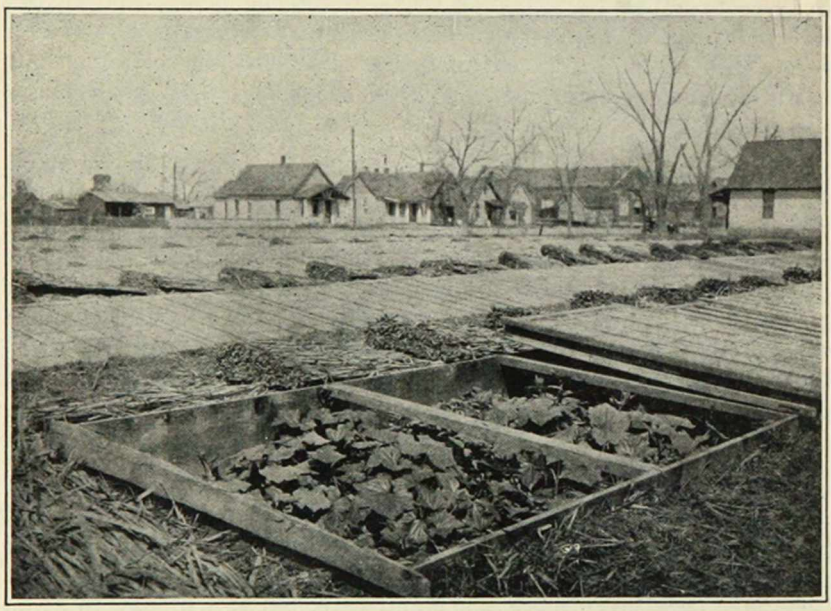

Figure 1.—Growing early cucumbers in hotbeds near Denver.

also made which use hot air or hot water as a source of heat. These have the advantage that any desired temperature can be maintained at all times, but because they are rather expensive and therefore are not suited to the needs of the average vegetable grower, they will not be considered further in this bulletin.

Location.—If it is possible to choose the location, the hotbed should be placed on a well-drained piece of ground, preferably with a southern slope, and close to an abundant supply of water. It is well to place the hotbed on the south side of the farm buildings if possible to obtain the effects of the windbreak afforded by the buildings. If the hotbed must be placed in the open, some sort of windbreak should be provided. The best sort is a fence of boards 5 or 6 feet high. The slope of a hill also provides some protection.

There are two general types of manure-heated hotbeds: the permanent hotbed and the temporary hotbed.

Permanent Hotbeds.—The permanent hotbed is usually used by the vegetable grower who has been in the business for a number of years and has a definite idea of his operations from year to year. It consists of four essential parts: the pit, the frame, the sashes, and the sash covers. The hotbed pit is dug 18 to 24 inches deep, 6 feet wide, and as long east and west as is needed. The pit should be dug in the fall before severe freezing weather and filled with straw or

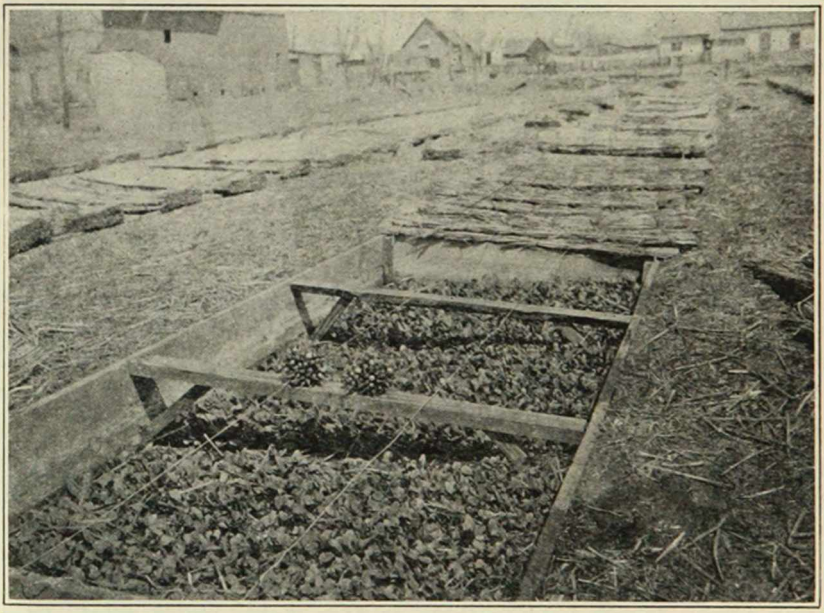

Figure 2.—Forcing radishes in hotbeds for the early market. Notice that no sash is used but mats are supported by wires.

litter to keep the walls from freezing and crumbling during the winter. If permanent walls are to be used they should be put in at this time. It is often impossible to dig a pit satisfactorily in the spring on account of snow and frozen or wet ground. If the walls of the pit are frozen, much of the early heat generated by the manure is used in thawing them out.

The hotbed frame may be made of brick, hollow tile, reinforced concrete, or boards. Reinforced concrete is probably the most lasting and most satisfactory of these materials, but boards are usually more applicable to the conditions of the average farmer. The board frame, if constructed properly, will last for several years and can be made so that it can be taken up and stored each year after the sea-

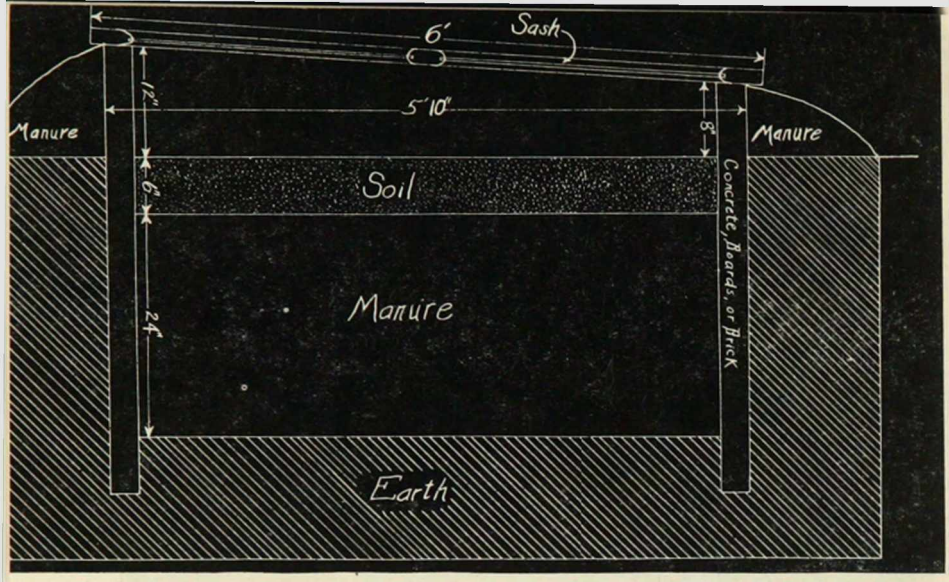

Figure 3.—Cross-section of a permanent manure-heated hotbed.

son is over. The frame should be made of boards 1½ to 2 inches thick. It can be made to extend to the bottom of the pit or down only a few inches, just as the grower prefers.

The easiest to handle and one of the most satisfactory types of frame is that shown in figure 3. It is made of boards 1½ or 2 inches thick and extends down only a few inches into the bottom of the pit. It rises 12 inches above the soil level on the north side and 8 inches on the south side. This gives a slope to the south which allows the sun to penetrate easily. This sort of frame can be made in sections of a size to hold any number of sashes. The most convenient-sized section is one holding three or four sashes which would be 9 or 12 feet long and 6 feet wide. There is, of course, a crossbar every 3 feet for the sash to rest upon. The crossbar should be 4 inches wide and 1 inch thick. A light iron T-beam 2 inches wide may also be used for this. The crossbar should be fastened in such a way that it may readily be taken out for storage over winter. The frame sections may be fastened together in such a way that they can be taken apart and stored inside during the winter.

This kind of frame is easily put upon the pit and easily taken off and stored. The frame can be removed and the pit easily cleaned after the plants are gone. This kind of frame also makes it possible to change the location of the hotbed every year and thus avoid the accumulative effects of diseases in the bed. It produces as high-quality plants as any other sort, and, if taken care of, will last for a number of years.

Sash.—The standard sash used in hotbeds is 3 feet wide and 6 feet long, like that shown in figure 4. It should be made of cedar or cypress and may be bought glazed or unglazed. If the grower has the facilities for glazing, it is often cheaper to buy unglazed sash and glaze it himself. Sash varies in thickness, but 1½ inches is a good weight since it is easily handled and is durable when given proper care.

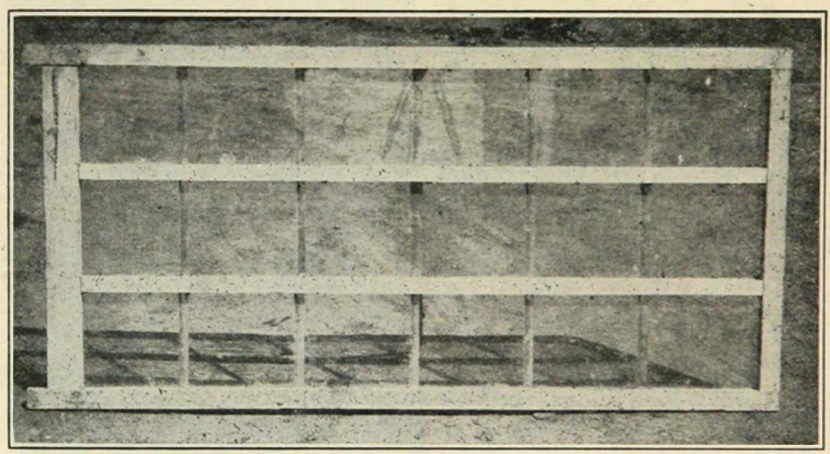

Figure 4.—The standard single pane sash used on hotbeds and coldframes.

Double-glass sash is sometimes used. It has these advantages: (1) It is almost as warm as single sash covered with reed mats; (2) there is less labor in managing frames because there are no mats to handle; (3) the plants receive light all day, since there are no mats to obstruct it; and (4) the bed warms up earlier in the day and stays warm longer. The disadvantages of double sash are: (1) It is heavier to handle; (2) it costs about one-third more; (3) moisture accumulates between the panes and it is therefore doubtful whether double sash is as durable as single sash; and (4) dirt often accumulates betwen the panes, thus reducing the amount of light that reaches the plants. This reduction of light is often enough to produce weak plants.

It is usually best to buy single-glass sash and cover it with reed mats during periods of cold weather. Mats such as those shown in figure 5 will thoroughly cover one sash. They efficiently protect the bed during any unusual weather.

Glass Substitutes.—During the past few years there have been many glass substitutes on the market to be used for hotbed and coldframe protection. So far glass is probably more satisfactory,

since it permits more sunlight to pass through to the bed and plants. The glass substitutes do not permit the beds to warm up as quickly in the early part of the day. The glass substitute on wire netting is harder to clean by washing, since dust and sediment stick to the surface. It is lighter in weight and must be weighted down or held on the beds by holding attachments to prevent wind from blowing it off.

The glass substitutes seem to be of some value for shading during the germination of small seeds like celery, but after the seedlings are well started, substitutes seem to produce more spindly plants. More artificial heat, of course, would be necessary when sunlight does not pass through the sash readily.

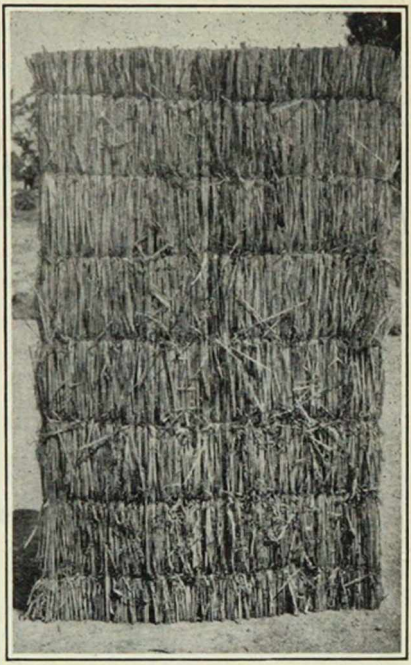

Figure 5.—Reed mat used for protection on hotbed or coldframe in cold weather.

Temporary Hotbeds.— The most common type of temporary hotbed is that shown in figure 6. The principal advantages of this type are that it is easily constructed and that it can be used in locations where the soil is too poorly drained to permit the use of a permanent hotbed. The temporary hotbed has the disadvantages of requiring more manure and of being harder to protect from winds. Its use is never recommended where a permanent bed can be used.

The construction of the temporary hotbed is very simple. The pile of heating manure is leveled off, the hotbed frame placed upon it, manure banked up around the frame, 4 to 6 inches of soil placed in the frame, the sash put on, and the whole managed the same as a permanent hotbed.

Preparation of Manure.—The heat of the hotbed is provided by the bacterial fermentation of manure. Horse manure is used almost entirely for hotbeds.

The best results are obtained by using fresh horse manure from grain-fed animals. The manure should contain one-third straw or similar litter which is commonly used in bedding. Manure contain-

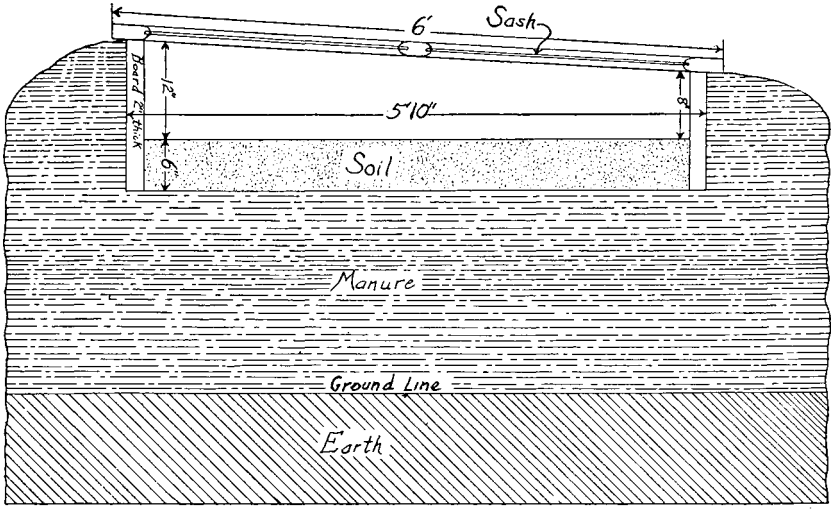

Figure 6.—Cross-section of a temporary hotbed.

ing wood shavings is not satisfactory and should not be used. If the manure does not contain litter it often will not ferment, and if it does ferment the action is liable to be so violent and of such short duration that it is worthless for hotbed use. If there is too much litter in the manure the period of heating is often too short to be of any practical value, because the bacteria soon use up all the fermentable part of the manure.

From 10 to 14 days before the manure is to be put into the pit it should be placed in a pile 4 to 5 feet wide and 3 to 4 feet high and the length required for the bed. If it appears dry it should be dampened with warm water but should never be wetted enough to become soggy. In 3 to 5 days, depending on the quality of the manure and the warmth of the weather, the manure will start to heat. When it has heated for a day or two it should be repiled with the outside of the pile in the middle and all lumps well broken up. Any dry spots appearing at this time should be dampened with water, preferably warm but not hot. Repiling the manure insures uniform heating throughout the pile, which is necessary for good results in the hotbed. It will sometimes be necessary to repile the manure two or three times to secure uniform heating, but once is usually enough. If the hotbed is near a shed of any sort it is best to pile the manure under the shed to heat or, if this isn't possible, to construct near the hotbed a cheap shelter under which to pile the manure. This prevents the possible loss of the heat from the manure from heavy rains, which will usually prevent the manure from fermenting at all. A

shelter is therefore especially desirable when large hotbeds are made, making necessary the use of large quantities of valuable manure.

When the piled manure is heated uniformly throughout it should be placed in the hotbed pit in layers of 5 or 6 inches at a time and tramped thoroughly, especially around the edges. This tramping prevents uneven heating in the bed, and the manure settles very little. The manure should be dampened if it seems to be dry.

If portable frames are used they should be put in place after the pit is filled with manure. The sashes should be put on at this time to guard against rains which would, if very heavy, prevent further heating of the manure. The manure will gradually heat to a high temperature and then gradually cool down. When it has cooled down to about 85° F. the seed can be safely sown. If seeds are sown at a temperature much higher than 85° F. there is danger of the germination being impaired.

The Soil.—The soil may be put in the frame either when the pit is filled with manure or when the temperature is low enough for safe planting of the seed. If it is put in when the pit is filled the high temperature may kill most of the weed seed present in the soil and the soil will be warmed up so that the crop seed will germinate readily when planted.

Various kinds of soil mixtures are used for hotbeds. A fairly fertile sandy loam containing plenty of humus is usually satisfactory. A too rich soil is not desirable because the plants tend to become succulent and are difficult to harden off and transplant successfully. One soil that is used extensively for hotbeds is made up of one-fourth sand, one-fourth well-rotted manure, and one-half good garden loam. Leafmold, rotted sod, or rotted straw may be used instead of manure. Some growers use a compost made by piling blue-grass sod and barnyard manure in alternate layers 8 to 10 inches thick with the pile about 5 to 7 feet high. This compost should be made at least 8 months before the soil is to be used. Any coarse material in the compost should be removed and the remainder put in the hotbeds. Whatever soil is used should be moderately fertile, should contain enough organic matter to hold water and be loose and friable, and should contain enough sand to warm up readily and to drain easily.

The soil is placed in a layer 4 to 6 inches deep on top of the manure in the hotbed. The greater depth is used for radishes and root crops with similar growing habits. If the seeds are sown in flats, 2 inches of soil or sand on top of the manure is sufficient. This thin layer allows the heat to reach and warm up the soil in the flats and the plants will grow as well as if they were planted in the soil in the bed.

The same soil that is used in the hotbed may be used for sowing seed in flats. If the grower prefers a lighter and more porous soil he should add enough sand to make the soil mixture about one-third sand. Well-rotted leafmold mixed with one-third sand is one of the best soils to use for seeding in flats. It allows the plant roots plenty of room for expansion and is also loose enough that the plants can be pulled for transplanting with very little root injury.

Time to Start the Hotbed.—The time at which the hotbed should be started is governed mainly by the time at which the plants can be set out safely in the field. The date of starting the hotbed also depends upon the type of plant to be grown and upon its treatment before setting in the field. Tender plants like tomatoes, eggplants, and peppers cannot be safely planted out until long after the half-hardy plants such as cabbage, lettuce, cauliflower, and celery. Therefore the hotbed must be started later for tomatoes than for celery and similar crops. If the plants are to be transplanted from the hotbed to coldframes to grow until set in the field, the seed may be sown earlier than is the case when they are not to be transplanted previous to setting in the field. Briefly, then, the time of starting the hotbed depends upon the type of plant, the treatment the seedlings receive before setting in the field, and the time at which they can be safely transplanted to the field. It is well to allow 8 weeks from the time the seeds are sown until the normal time of setting in the field. This allows plenty of time to grow a healthy, vigorous plant and also plenty of time in which to harden it properly for transplanting. Another 2 weeks should be allowed for preparing the manure and the seedbed for seeding. The great diversity of climatic conditions in Colorado makes it almost impossible to give definite dates for sowing seed.

Early cabbage seed can be planted about 6 to 8 weeks before time for field setting. Tomatoes, peppers, and eggplant require about 8 weeks to grow if they are to be transplanted direct from the plant-growing beds to the field.

Electrically Heated Hotbeds

During the past few years there has been considerable interest in the use of electricity in heating soil in hotbeds, and for that reason it is discussed here even though it may be impossible to obtain materials for this type of hotbed during the war.

The electric heating cable which is placed in the soil is made of nichochrome resistance wire wrapped with asbestos paper, jute, or other insulating material and the whole covered with a lead sheath. The diameter varies with the different makes from 3/16 to ½ inch. There are, of course, many economic questions to be answered as far as electric soil heating is concerned.

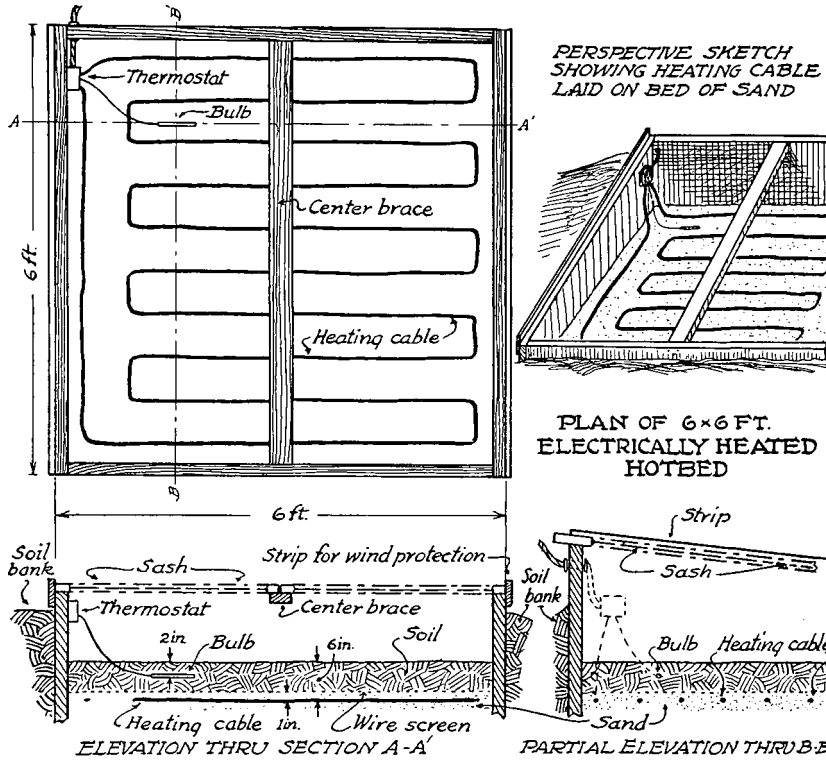

Figure 7.—Plan for electrically heated hotbed in which heating cable is used.

Advantages of the Electrically Heated Hotbed.—1. Equipment, when permanently installed and properly taken care of, will last several years.

2. Uniform temperatures can be maintained by thermostatic control.

3. It is always ready to use.

4. Some equipment can be transferred to the greenhouse and used in propagating or cutting beds.

5. Soil moisture can be held more uniform and seedling disease losses reduced.

6. It can be used for late fall plantings.

7. It eliminates the need for manure which is becoming more difficult to obtain and which does not maintain a uniform temperature during the plant-growing period.

8. It can be used as a coldframe by turning off the electricity.

Installation of Cable for Under-Soil Heating.—The heating cable can be placed at a depth of 6 inches under the soil surface. The spacing between cables should be about 7 inches, which will make it possible to have five loops or coils per 3 x 6-foot sash. The longer the cable the more resistance is created, so that increasing the length of the cable lowers the amount of heat produced. It is therefore necessary to use standard lengths, and the local power company should be consulted on the circuit voltage, ohm resistance of the cable, and the watts for length of cable.

In order to protect the cable from damage during removal of the soil, a fine wire screen may be placed an inch above the cable. Fine sand is poured around the cable first and then the protecting screen placed over the cable. Two or three inches of straw or strawy manure will be of some protective value, and wooden protecting frames can be used in place of wire screen.

A thermostat can be installed at a convenient location under 2 inches of soil if the bulb type is used. Hand switches may be used in place of a thermostat if the operator desires such an arrangement in place of an automatic control.

Recent research indicates that placing the cable on top of the soil after planting is also an effective method of heating hotbeds.

Cost of Operation.—The cost of operation is variable and depends upon the insulation of the hotbeds, the outdoor weather conditions during the period of use, electricity rates, ventilation methods, and plants or crop grown. Use of 30 to 120 kilowatt hours per 3 x 6-foot sash during a period of 6 to 12 weeks has been reported.

Heat furnished for hotbeds from fermentation of manure, by hot air, steam, or electricity is to supplement the heat furnished by the sun's rays. Therefore, construction of the hotbeds to prevent heat losses will cut down operating costs. Protection from cold winds, the use of mat covers for sash, tight-fitting sash, freedom from open cracks in the frames, slope, and drainage—all are important factors in reducing heating losses. It is important that hotbeds be checked for heat losses and especially so where electricity is used for heating.

Many details have not been discussed, and it is recommended that those planning electric installation get in touch with their local power company or electrician for information on electricity rates, proper installation of electrical equipment, electric cable, and other necessary supplies.

Care and Management of the Hotbed

Sowing the Seed.—When a temperature of 85° F. has been reached in the hotbed the seed should be sown. Seed may be sown broadcast or in rows. Sowing in rows is preferred, since a better stand is usually obtained and there is better ventilation among the plants. The rows should be 3 inches apart and across the bed from front to back. The soil should be perfectly level after seeding in order to prevent uneven watering of the bed by water settling in the lower spots. The bed should be watered with a fine spray immediately after sowing. A hose, unless used very carefully, has too much tendency to wash out the seed. After small seeds are sown it is advisable to cover the bed with cheesecloth, burlap, or similar material and then water through the cloth. This minimizes washing and also favors germination by holding the moisture near the seed. The cloth should be removed as soon as germination begins.

Seed may also be sown in small flats or boxes. The soil is placed in the flat, leveled, and firmed so that there is not any excessive settling of the soil after watering. Depending on size, seed is sown at the rate of 10 to 12 seeds per inch and is covered with ¼ to ½ inch of soil. The seedlings should be transplanted from seed flats into other flats or to hotbeds or coldframes after the first true leaves are formed. It is important that this be done before crowding occurs in the seed flat. A spotting or marking board can be used in transplanting from the seed flats to other flats. (See fig. 9.)

Ventilation

The main object of ventilation is (1) to control temperature, (2) to control humidity, and (3) to provide fresh air. Proper temperature conditions are absolutely necessary to grow good plants. Soft plants can be produced by too high temperatures and lack of ventilation. Overwatering is also conducive to the growth of soft plants and damping-off diseases. Lack of ventilation and insufficient watering may cause wilting of the plants. Chilling the plants should likewise be avoided. Temperature can be controlled by admitting fresh air around the plants and carefully checking the outside temperatures so that draft and sudden changes are avoided.

Fresh air is as essential to optimum plant growth as is the correct temperature. Without plenty of fresh air the bed does not dry out well and diseases, especially "damping off", are likely to start. Those plants that do not become diseased usually become weak and tender if they go very long without fresh air. During periods of weather when it is so cold or snowy that the sash must be left down all the time, the amount of watering should be decreased, since the excess water increases the humidity, causing the plants to become

weak and succulent. Then when the weather warms up it is very difficult to ventilate them properly without injury. Drafts should be avoided at all times, since they always slow up the growth of the plants and in many cases stunt them permanently. Drafts can be avoided by raising the side or the end of the sash away from the wind. As the outside temperature rises, the amount of ventilation should, of course, be increased. When the weather is very cold the sash should be closed earlier in the afternoon to prevent the heat from escaping from the bed.

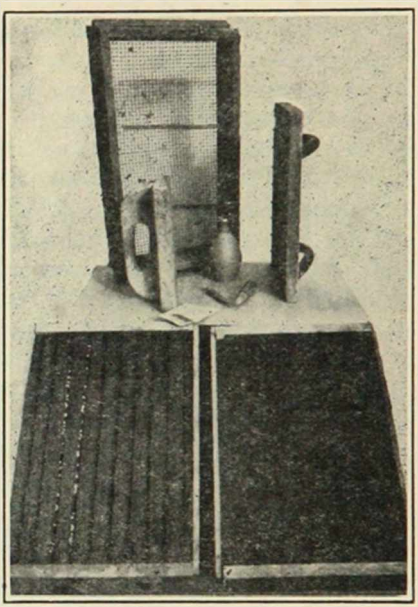

Figure 9.—Seeding in a flat (left) and flat prepared for transplanting, with equipment used (above). Top left, soil screen; bottom left, soil firmer; center, watering syringe and planting dibbles for transplanting; right, spotting board for marking flat for transplanting seedlings.

Temperature

The ideal plant-growing temperature for cool-season vegetable crops is between 60° and 70° F. during the day. Such crops include cabbage, cauliflower, celery, and head lettuce. Warm-season crops such as tomatoes, eggplant, and peppers do well at day temperatures of 65° to 75° F. In either case, night temperatures should not be permitted to drop more than 5° to 10° lower than day temperatures.

Low temperatures can cause premature seeding in celery, beets, and cabbage. This is especially true when very cold weather prevails during April and May. Research has shown that small celery plants will send up premature seed stalks if grown at temperature ranging from 40° to 50° F. for 2 weeks or longer. Growth checks due to freezing or drying out of the plants delays premature seeding of celery; however, the chilling temperature range may cause premature seeding. Similar temperature ranges were found to favor premature seeding in cabbage. Plants which go to seed are unmarketable, and therefore, temperature controls are important to good plant production. There is considerable difference between strains and varieties in the amount of premature seeding which develops after chilling.

Watering

The growing seedlings in the hotbed must have plenty of water for good growth, but care must be taken to prevent overwatering. The amount of water needed depends upon the temperature, the humidity, and the amount of sunshine. Because of the danger of packing or puddling soil and chilling plants, water should be carefully applied. Soaking of the manure from overwatering will check fermentation and heat production. Better results are always obtained by watering infrequently and thoroughly than by making frequent light waterings. When light watering is practiced every day or oftener, the water seldom penetrates deeply enough to reach the root system of the plants and wets only the top soil. Under these conditions it is quite possible for the plants to be suffering from lack of water even though they have been watered recently. It is best to water the bed thoroughly, and then let it go until the soil is dried out for a few inches below the surface. Very little water will be needed during February and March, because of the higher humidity and the greater number of cloudy days at that time. Much more will be needed during April and early May.

Watering should be done in the morning and only on sunny days unless it becomes necessary during a long period of cloudy weather. If possible, the water should be at a temperature of 60° to 65° F. when applied. If water is applied in early morning at this temperature the difference between the temperature of the plant and the water is small and the danger from cold shock is not as great as it would be later in the day when the plants would be warmer than the water. If the plants are watered late in the day when the temperature is falling, the water will cause the temperature of the bed to fall unusually low during the night and there is danger of severely shocking the plants. If watered in the morning when the temperature is rising this danger is eliminated and the plants and top soil are dried off and warm long before night.

Transplanting

Seedlings may be transplanted to flats, coldframes, hotbeds or to outdoor plant beds. The principal advantage in transplanting before setting in the field is the saving of hotbed and greenhouse space. Research has shown that transplanting cabbage twice before field setting greatly reduced yields. Roots are destroyed in transplanting; the damage done varies with the method used and the size of the plant. The larger the plant the more difficult it is to transplant without damage to the root system. Recovery from transplanting is associated with the speed of root replacement, and that varies with different vegetable crops. Broccoli, cabbage, cauliflower, and lettuce transplant easily. Celery, peppers, and eggplant do not transplant

as well, while corn, vine crops, and beans are very difficult to transplant satisfactorily.

Pruning at Transplanting Time.—Recent research indicates that removing the foliage of cauliflower, celery, and headlettuce plants has no advantage and need not be done. Heavy cutting back of the foliage of cauliflower plants at transplanting time caused a delay in maturity and oftentimes a reduction in yield. Light pruning of the foliage did not produce any important effect on earliness or total yield of cauliflower plants. Pruning small cauliflower plants and pruning large plants resulted in no difference in growth. Pruning large celery plants was more harmful than pruning small ones. Rate and amount of root growth of cauliflower and celery plants was reduced in proportion to the amount of leaf area removed by pruning.

Transplanting to Flats.—When transplanted into the coldframes or other hotbeds, the plants are usually placed in rows 3 to 4 inches apart and about 1 inch apart in the rows. This gives the seedlings ample room to develop into strong, healthy plants which are necessary for the production of successful crops. Plants may be set in squares about 2 inches each way instead of in rows. When the plants are transplanted into flats as shown in figure 8 they are set 1 inch apart each way. The flats are then usually placed in a coldframe and the plants hardened off before setting in the field. This is one of the most satisfactory methods, since the flats can be taken directly to the field for setting out. A ball of earth can be lifted from the flats with the plants. This gives very little chance for the plants to dry out during transplanting.

In many cases the grower feels that he can afford to make but one transplanting, that from the hotbed to the field. In such cases the plants should be thinned as soon as the third leaf is formed. The weak, crooked, and diseased plants should be removed and only sturdy, vigorous plants left to stand, on the average, 1 inch apart in the rows in the hotbed. They should be ventilated and watered carefully until ready for setting out permanently in the field. These plants can be hardened off as successfully as those in the coldframes, since the heat of the manure is gone long before the plants are ready for setting in the field, and the hotbed is then essentially a coldframe.

Transplanting to the Field.—Much care should be taken when the plants are transplanted to the field. If the plants are not properly cared for when transplanted, the resulting crop will be only a partial success and a big disappointment to the grower. Transplanting will always be successful if the following principles are observed:

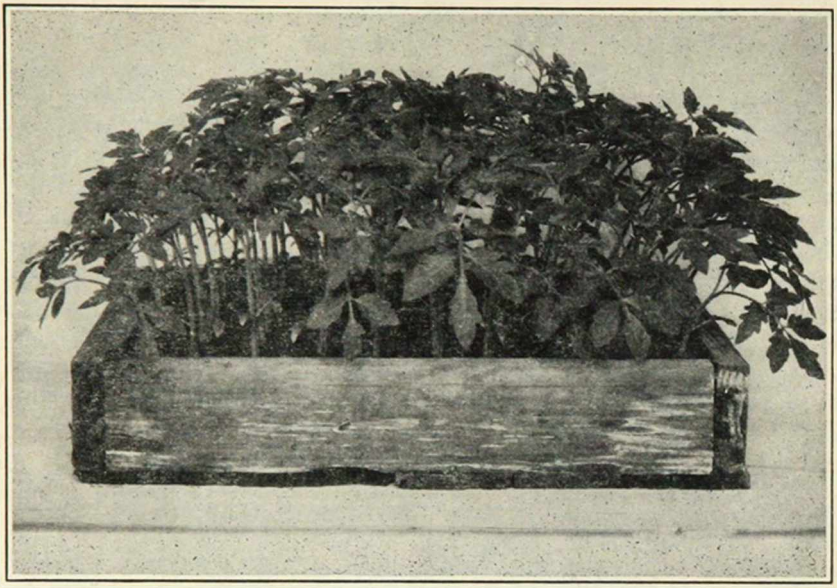

Figure 8.—Tomato plants transplanted to a flat.

1. Never let the plants become dry, but keep them moist from the time they are removed from the bed until they are set in the field.

2. Break as few roots as possible when removing plants from the bed. Always loosen the soil about them and remove a ball of earth with each plant.

3. Always pack the soil firmly about the roots of the plants and up to the surface. Leave some loose surface soil about the plants to prevent baking of the soil.

Starter Solutions.—In the East where mechanical transplanters are used more than in Colorado, growers have been adding a fertilizer mixture to the water at transplanting time. The starter solutions are applied immediately around the roots when the plants are set in the field. Increased early yields have been obtained by their use. Plants become established earlier and there is less loss of plants. Starter solutions have been tried on tomatoes in the Arkansas Valley and early growth was increased by the use of a 6-30-0 mixture. This mixture consists of 6 parts of nitrogen, 30 parts of phosphoric acid, and no potash. Five pounds of the fertilizer were added to fifty gallons of water and about ¼ pint of the solution was used with each plant when set in the field. The cost of the fertilizer is relatively small per acre, although application of the solution by hand

methods makes it more difficult to use. About 100 gallons is used per acre and the cost of material varies between 50 and 80 cents per acre. The response under irrigation will vary with soil fertility levels, temperature conditions at transplanting time, and crops grown. Starter solutions should not be considered a substitute for field fertilization but only as a supplemental practice.

Hardening Plants

Hardening of plants consists in regulating growing conditions so that plants are conditioned to withstand adverse outdoor conditions, such as light frosts, hot, dry winds, or insect injury, when set in the field. Plants are hardened by checking the growth. Checking growth by gradually withholding water for a week to 10 days before field transplanting and gradually lowering the temperature are the methods used. Also, a deficiency of nitrogen in the soil may harden the plants. Caution must be observed to prevent stunting the growth by too severe hardening, for many growers harden the plants too much and growth in the field is definitely delayed after transplanting.

Not all plants can be hardened to the same degree. Cabbage, cauliflower, and broccoli can be hardened to withstand light frosts, but research has shown that hardening of tomato plants checks growth and may reduce early yields regardless of variety used. Hardening of tomatoes by severe growth checks may cause an increase in the percentage of poorly formed fruits on the first cluster. Tomato plants should be hardened only slightly if at all.

Disease and Insect Control

Serious losses of plants from diseases and insects can often be traced to careless management and lack of attention to detail in growing the plants. Preventive measures and precautions taken earlier will be more successful than attempts to cure diseases and combat insects after they are well started. Not only is it important to know type, yield, and time of maturity of vegetable varieties in buying seed, but the purchaser should also know if the seed purchased is from a disease-free source. Soil sterilization and sanitation measures are important in control of diseases and insects. More details can be found in Extension Circular D-8, "Damping-Off and Its Control" and Circular D-6 "Vegetable-Crop Pests."

Coldframes

A coldframe is constructed in the same way as a hotbed except there is no source of bottom heat. The coldframe depends entirely upon the sun for its heat during the day and upon the sash and mats or other covers for the retention of heat at night. For this reason

the coldframe cannot always be used for the same purposes as a hotbed, but one must supplement the other for best results.

Uses of the Coldframe.—The principal uses of the coldframe are: To harden off early plants grown in the hotbed, to start medium early and late vegetables and flowering plants, to raise to maturity early spring and late fall crops of lettuce and radishes, and to carry half-hardy perennials through the winter. The coldframe may be used as a storage for celery and root crops if the winter temperature does not go too low.

Most growers should have both hotbeds and coldframes in order to operate most efficiently. They can then start plants very early in the hotbed and harden them off in the coldframe. The coldframe is also handy for hardening plants started in greenhouses. In case the grower does not wish to construct both hotbeds and coldframes he should construct hotbeds rather than coldframes. Plants can be started much sooner in a hotbed than they can in a coldframe and the hotbed may used as a coldframe for hardening the plants after the heat of the manure is spent. This saves transplanting from the hotbed to the coldframe and is the most practicable method when the grower does not operate on a large enough scale to warrant the use of both hotbeds and coldframes.

The construction of the coldframe is essentially the same as that previously described for the hotbed. The frame may be permanent or temporary. The permanent frame may be made of brick, concrete, or heavy boards. Very little pit is needed, since there is no manure put in for heating purposes. However, if the coldframe is to be used as a storage pit for half-hardy flowers or for vegetables, an excavation of 2 to 3 feet is needed. A few inches of sand or cinders should then be put in the frame and flower pots plunged to the rim.

The temporary coldframe does not require a pit and may be set on the ground. A soil such as described for hotbeds should be supplied for the plants. The frame should be thoroughly banked around to shut out the cold. For convenience in fitting sash the frame should be of the same width as the hotbed frame. The length is, of course, governed by the amount of plants to be grown.

Management.—The general management of the coldframe is the same as is that for the hotbed. The soil, seeding, watering, and transplanting requirements are the same. The coldframe does not require as much ventilation as the hotbed, because it seldom reaches as high a temperature as the hotbed. However, the seedlings should be given as much air as possible without danger of drafts or frosts. A temperature of 55° to 65° should be maintained, if possible, while

the seedlings are small. The plants should be thoroughly hardened by giving them more and more air until a week or 10 days before setting in the field. The sashes should be removed entirely for the last few days before transplanting.

Amount of Sash Needed.—The size of hotbed or coldframe will depend upon the amount of crop to be raised, upon the crop under consideration, and upon the method of handling the seedlings before transplanting to the field. If the seedlings are to be hardened in the hotbed, the large plants such as tomatoes and peppers should be thinned to stand about 1 inch apart when the first few leaves appear. This will give 75 plants per row across the bed and if the rows are 3 inches apart there are 12 rows per sash or 900 plants per sash. For the smaller plants such as celery, cabbage, and cauliflower the grower can raise up to transplanting size about 2,000 healthy plants per sash. In case the seedlings are to be transplanted to a coldframe for hardening there is no advantage in thinning them in the hotbed. Only the more vigorous plants should be transplanted to the coldframes.

It requires more coldframe space than hotbed space for the same number of plants because the plants are always given more room in the coldframe so that they will become sturdy and vigorous. Peppers, tomatoes, and eggplants should be set in rows 3 inches apart and 2 inches apart in the row. This will give about 425 plants per sash. Cabbage, cauliflower, and celery should be set in rows 3 inches apart and 1 inch apart in the row, which will give 850 plants per sash. The requirements of all other crops will be similar to those of some one of these crops and the amount of space needed by them can be determined by comparison of growth with one of these crops.

The number of acres of the crop to be grown determines the number of sashes needed. This can be figured by dividing the number of plants required per acre by the number of plants per sash and multiplying by the number of acres or fraction of an acre to be planted. This will give the required number of sashes. The following table may be used as a guide in determining the number of plants required. These figures are, of course, for average planting

Crop	Plants per acre
Cabbage	12,000 - 13,000
Cauliflower	12,000 - 13,000
Celery	20,000 - 30,000
Eggplant	7,000 - 8,000
Onions	80,000
Peppers	10,000
Tomatoes	4,000 - 6,000

distances and will vary with different planting distances that the grower may prefer.

The number of plants required per acre can be determined by multiplying the width in feet between rows by the distance in feet between plants in the row. This gives the number of square feet required per plant. Then 43,560 (the number of square feet per acre) is divided by the square feet required per plant to get the number of plants per acre. Then the number of hotbed or coldframe sashes can be calculated as explained.

Growing Plants in Pots and Bands

In the last few years there have been placed on the market a number of different sorts of pots and bands in which to start plants. They are made of paper, wood veneer, and similar substances. The latest to appear is a pot made of pure peat. Some of these devices are said to give good results, but they have not been investigated thoroughly enough by the Experiment Station to warrant any recommendation concerning their value. Their cost relative to producing plants by other means should be fully investigated by the grower before he invests too heavily.

The bands, either paper or wood veneer, may be preferred to pots because they are easier to handle and are much more economical of space. The advantages of using bands rather than planting directly into the hotbed are:

1. Plants such as melons and cucumbers, which are very difficult to transplant successfully, may be started in bands and an early crop obtained.

2. Plants which ordinarily are not started indoors may be grown in bands to get an early crop.

3. Crops can be produced earlier with nearly all plants because there is not the usual shock in transplanting.

4. The labor of shifting and transplanting is greatly reduced and consequently the cost of production is reduced.

5. The plant is transplanted with little shock, since its roots are disturbed very little.

6. Plants can be shipped more easily and more satisfactorily when grown in bands.

7. There is less danger of loss from drying out when the plants are set out in the field.

The bands are placed side by side in the hotbed or coldframe or in flats either in the hotbed or coldframe. The flat is very con-

venient for handling bands, since the labor of shifting plants is greatly reduced and it is much easier to move the plants when transplanting. The size of band to use depends somewhat upon the crop to be grown, but the sizes most used for garden crops are 4 x 4 x 3 inches and 4 x 4 x 4 inches. Smaller sizes can be obtained and can be used successfully if the plants are not to be left in them for a very long time.

A thin layer of compost is put in the bottom of the bands and they are then filled with a good grade of garden soil that will not pack. Six to eight seeds should be sown in each band 4 to 6 weeks before time for field setting. If sown much before this the plants may become crowded and tender and be slow to start growth after transplanting.

After the seed is sown the same care must be exercised as in the hotbed. As nearly as possible a day temperature of 70° to 75° F. should be maintained until the seeds germinate. Then the day temperature should be kept at 60° to 65° F. and the night temperature at 60° F. until about a week before planting, when the temperature should be gradually lowered in order to harden the plants.

When the first true leaves appear, the plants should be thinned to three per band and when they are growing well they should be thinned to one or two plants for field setting.

Plants should be removed to the field while still in the bands. A hole is then dug for each plant, the band removed, and the plant with the attached earth placed in the hole and the earth pressed firmly around it. If extremely dry weather prevails at transplanting time it is advisable to wet the soil in the band thoroughly before transplanting. This will prevent wilting with its consequent setback.

Seed of tomatoes, cabbage, and similar plants that are easily transplanted may be sown in flats, pricked off into other flats when they show a few leaves, and later transplanted permanently into bands for growing until time to plant them in the field. Transplanting should be done about a month before setting in the field. By using this method rather than sowing the seed directly in the bands the grower may save a great deal of space during the early life of the plants. With melons, cucumbers, beans, squash, and similar plants that will not stand any transplanting, the seed should be sown directly into the bands.

Plant Protectors

Often the grower is anxious to mature a crop at the earliest possible time. In this case plants must be set out at the first warm period after winter is over. Since these warm periods are quite often

followed by cold weather for a few days, the grower must provide some means of protection for the early plants in the field or take the chance of getting them killed by frost. To protect plants in the field, various sorts of plant protectors are used. The kind depends somewhat upon the individual preferences of the grower, since the protectors are all very similar. They can be purchased from a number of firms, and full directions for their use are always included. The results obtained from their use varies with the climatic conditions of the various seasons. They are of most benefit during cold, late springs which have alternate cold and warm periods of weather. They require considerable labor and attention and are fairly expensive. Therefore their use is not generally recommended except in those cases in which the grower wishes to produce an especially early crop for a special market. If weather is warm, plant protectors may force rapid spindling growth of plants, so that ventilation is necessary. Small openings on the side opposite the prevailing wind are helpful. The caps should be split a few days before their removal.