GARDEN SOIL *Management*

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SUMMARY

1. The soil is the most important factor influencing good yields and quality of vegetables in the garden.
2. An ideal garden soil is one that is free-working and high in fertility.
3. The most important need of the average garden soil is organic matter.
4. Stable manure is a valuable source of organic matter and is one of the best garden fertilizers.
5. Gardens should be protected each winter by growing cover crops to supply organic matter.
6. Legumes make the best cover crops because they supply nitrogen as well as organic matter.
7. Important sources of organic matter include crop residues, sod, leaves, straw, lawn clippings, and other bulky organic materials.
8. Most vegetables prefer a slightly acid soil. If beets or spinach grow well it is an indication the soil does not need liming.
9. Commercial fertilizers can be used to supply readily available plant foods, but they do not serve as a substitute for manures or cover crops in contributing organic matter.
10. Nitrogen is more likely to be a determining factor in crop growth than phosphoric acid or potash.
11. Phosphoric acid is valuable in stimulating root growth, encouraging blossom formation, and hastening maturity.
12. Potash is especially useful in the growing of roots, and of fruiting and leafy crops.
13. Fertilizer supplies are limited because of the war. They should be used properly, in amount and place.
14. Booster or starter solutions, consisting of fertilizers soluble in water, are useful in stimulating plants to become more quickly established after being transplanted to the garden or field.
15. Thorough soil preparation is essential in gardening. There is no substitute for a good seedbed.
16. Cultivation or soil stirring in a garden can be limited to that necessary to remove weeds and maintain a good soil mulch. Shallow cultivation is more effective than deep cultivation.
17. Irrigation will pay on most gardens.

Garden Soil Management

by

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THE productivity of a vegetable garden is determined to a great extent by the soil. There are other factors that contribute to the garden's welfare and value, such as a full planting program, good seed, proper choice of varieties, irrigation, and control of pests. The fundamental factor determining yield and quality, nevertheless, is the soil itself when properly managed.

This bulletin considers the soil problems of the vegetable gardener and suggests ways and means of soil improvement, fertilization, and handling.

SOIL TILTH

A garden soil is rated on its physical structure or tilth as well as its fertility. In both of these two characteristics the soil used for vegetable growing should be superior to the average soil, because vegetable plants demand unusually favorable conditions to produce yields of good quantity and quality.

In view of the widespread production of vegetables in home gardens many different kinds of soil are utilized for vegetable growing. In certain cases the gardener is confronted with a naturally heavy soil that is composed largely of clay that may have poor drainage, may have compact and somewhat impervious structure, and in general be hard to manage. Again, the soil may be unusually light and porous and composed mainly of sand or silt particles. How can the physical structure or tilth of these and other types of soil be improved? The answer lies in adding to the soil some kind of organic matter. This is undoubtedly the most important need of the average garden soil, especially those soils located in city and suburban gardens.

GETTING ORGANIC MATTER INTO THE GARDEN SOIL

Samples of garden soil sent in to the Soils Department of Oregon State College frequently register a low amount of organic matter even though the plant food content shows a favorable analysis. Constant cropping and cultivation in the home garden deplete the organic matter of the soil unless it is definitely renewed.

Organic matter in a garden soil has many and varied benefits. It supplies food for beneficial microorganisms, increases water-holding capacity of the soil, maintains a good soil structure, improves soil aeration, adds plant food, and liberates plant nutrients. Roots are also stimulated by rotted organic matter, and a good root system is fundamental to a vigorous top growth of the vegetable plant.

Many home garden sites, especially in city gardens, are permanent and there is very little opportunity to change the location of the garden area; hence the soil organic matter of such gardens is constantly reduced by cropping. Farm garden sites are subject to change, although the home garden on the farm usually remains in the same place year after year because of being fenced and near the house. Most farms, however, have an available supply of some kind of manure that can be supplemented by a cover crop to provide an ample amount of organic matter.

If the garden is planted on the same area of soil yearly it is suggested that the location of the several crops in the garden be changed from year to year. This can readily be done by keeping a yearly plan of the garden layout.

Organic matter can be supplied in the garden soil by the use of: (1) cover crops, (2) manures, (3) crop residues, (4) composted materials, (5) lawn clippings, (6) leaves, and (7) straw.

Cover crops for soil improvement. Growing cover crops in the garden is a good way to increase the organic matter of the soil. Sometimes these crops are called green manure crops because they supply green plant tissue that is turned under the soil. Commercial vegetable growers find it necessary to include a green manure crop in the rotation in order to maintain the organic matter in their soils. Home gardeners should likewise grow and turn under a cover crop, even though it be grown only on a very small scale. Quickly growing crops such as vetch and barley or vetch and rye make good green manure crops for the small garden. They not only keep the home garden looking green through the winter but are valuable because they tend to prevent soluble plant food from being leached away during the winter by rains and snows.

Cover crops for western Oregon gardens include common vetch, 40 to 50 pounds of seed per acre, with winter barley 60 pounds; common vetch, 40 to 50 pounds of seed per acre, with winter rye 56 pounds, or common vetch 40 to 50 pounds, with winter oats 60 pounds.

In city and suburban gardens seed of the above crops may be sown soon after the early fall rains at the rate of about ¾ pound of

the seed mixture per square rod (272 square feet). Vetch grows quickly in the home garden and produces a large quantity of green manure to be turned under the following spring.

Crimson clover, 15 to 16 pounds per acre, is also a useful soil improvement crop, the seed of which should be fall sown. Cover crops for other areas of the state include Austrian winter peas, with or without winter wheat or rye; hairy vetch, sweet clover, and alsike clover.

The use of clover and alfalfa is usually confined to the commercial garden, because these crops are used in a fairly long rotation. Either clover or alfalfa land is fine for potatoes and other vegetable crops.

Cover crop seed can be sowed during the fall months between the rows of fall-harvested crops or directly on the ground as soon as previous crops have been removed. Any gardener having an available water supply has an excellent opportunity to get these crops started because of ability to moisten the ground before or after seeding.

Cover crops should be turned under the soil in the spring, preferably 3 weeks or more before seeding or transplanting, so that rotting may take place. They should be well mixed with the soil when turned under. Chemical nitrogen, widely used in aiding to break down green materials, is restricted in use during the war emergency and, therefore, cover crops should be turned under early enough to rot before the planting season. Because of the restriction of chemical fertilizers, it is more important, also, to use legumes rather than nonlegumes for garden cover crops.

Manures. Stable manures provide a desirable form of soil improvement material, particularly when straw is used for bedding. They contain highly valued organic matter and beneficial soil organisms. Manure as it is applied to garden land is usually about three-fourths water and one-fourth organic matter. The care of the manure determines its value, as the bulk of manure and organic matter value can be reduced 50 per cent in a few months of exposure to rainy weather. To prevent loss of organic matter and plant food, stable manure should be stored in a covered shed or hauled directly to the field, if soil conditions and cropping operations permit. The value of manures is discussed further under the heading of "Fertilizers."

Crop residues include any green material left over after a crop is harvested that may be available for plowing under the soil, such as bean, pea, and tomato vines, cabbage leaves, corn stalks and roots, stems and leaves of other vegetables. When turned under and

mixed with the garden soil these materials will usually rot more quickly than if put into a compost pile. They should be turned under the ground in the fall months so as to be thoroughly rotted by spring.

Crop residues of themselves will not provide a sufficient amount of organic matter to a garden soil and should be supplemented by cover crops or stable manure.

Lawn clippings often accumulate in considerable quantity and can be composted. They rot readily as they are high in nitrogen, and are useful in helping to decompose other material that rots less rapidly. Clippings may often be used to advantage as mulching material. (See page 21.)

Leaves vary in usefulness to improve the garden soil according to the kind and how they are used. The leaves of many of the ornamental and fruit trees make desirable organic matter.

There are two methods of using leaves: (1) putting them into a compost pile and turning the pile over at least once or twice a year in order that the leaves may have aeration to rot well; (2) turning leaves under the soil in the fall but not in the spring.

When composted in a pile, leaves require from 2 to 3 years to become good leaf-mold material for use in the garden or in soil mixtures for greenhouse and hotbed operations. Soil scattered among the layers of leaves will aid in quicker decomposition.

Straw, particularly of legumes, such as vetch, clover, and peas, adds both plant food and organic matter when returned to the garden soil. Legume straw rots readily if spread on top of the ground or mixed lightly with the top soil. It is useful also in the compost pile. Decomposition of grain straw requires an additional supply of nitrogen, and in view of the restrictions on chemical nitrogen the decomposition would best be accomplished by composting the grain straw with barnyard manure or legume straw.

Compost. Gardeners make common use of the compost pile to save crop residues and to rot organic matter. A layer of crop remnants, straw, or other organic material is composted about 1 foot deep at a time. The edges are made as nearly vertical as possible and the pile is made low in the center. On each layer is sprinkled sulphate of ammonia, superphosphate, and ground limestone or wood ashes at the rates of about $\frac{1}{4}$ to $\frac{1}{2}$ pound of sulphate of ammonia, $\frac{1}{4}$ pound of superphosphate, and $\frac{1}{4}$ pound of limestone or $\frac{1}{2}$ pound of wood ashes for each square yard of compost area. A few forks of old compost or rich soil mixed in will add soil organisms that will help rot the plant material. The pile must be kept constantly moist.

In the fall, if rains are excessive, the pile should be covered with tar-paper or boards to prevent leaching. Waste materials in the garden, such as leaves, grass, flower stalks, weeds, spoiled hay, etc., may be used in the compost. Materials that are known to carry disease or insects should be burned rather than composted. Legume straws are useful in supplying nitrogen for use by microorganisms that break down the more slowly decomposing organic matter.

SOIL REACTION

Soil acidity. It is important to consider the soil reaction* in connection with the fertilizer program. If the soil is definitely acid or alkaline it should be corrected before money is spent for fertilizing materials. Most vegetables make a satisfactory growth when the soil is slightly to moderately acid.* Beets, lettuce, spinach, and members of the cabbage family, do best in a soil that is about neutral.

If beets or spinach grow well in the garden it is a pretty safe indication that the soil is not acid and lime is not needed.

For correcting acidity, most vegetable growers use ground limestone from 1 to 2 tons per acre, according to the degree of acidity and type of soil. In a small garden this would amount to 12 to 18 pounds per square rod or 272 square feet. It should preferably be applied in the fall previous to seeding of the legume cover crop or in the spring during the preparation of the soil. Lime helps to improve the structure of heavy soils and creates conditions favorable for the growth of beneficial bacteria.

Wood ashes are a highly satisfactory form of lime, but they should not be dumped promiscuously and in large quantities on garden ground, which may be injured by their excessive use. Not more than 30 pounds of ashes to the square rod should be used and they should be scattered as much as possible at the time of applying. An alkaline soil condition, unfavorable to plant growth, develops when ashes are dumped in piles on the garden year after year. They should never be used on alkaline soils.

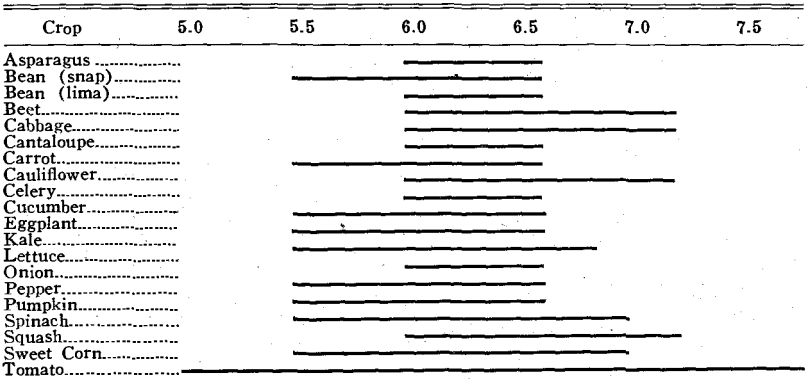
Soil tests for acidity can be made in the office of the local county agent or by the Soils Department of the Oregon Agricultural Experiment Station at Corvallis. Soil samples should be properly selected and submitted according to directions obtained from the Soils Department or the county agent.

Soil alkalinity. In correcting soil alkalinity, 10 to 15 pounds of sulphur should be applied per square rod of garden area. Am-

* See Table 1.

monium sulphate, 3 pounds per square rod, is also useful in correcting excessive alkalinity as well as in adding nitrogen.

Table 1. SUITABLE SOIL REACTIONS FOR VARIOUS VEGETABLE CROPS*



* The term soil reaction indicates relative acidity or alkalinity of a soil. pH 7.0 is neutral. A range of pH 7.0 to 6.4 represents a range of slight acidity; pH 6.4 to 5.8 represents a range of moderate acidity; pH 5.8 to 5.2 represents a range of medium acidity; and pH 5.2 to 4.7 a range of strong acidity. pH 7 to 7.5 represents a range of slight alkalinity; pH 7.5 to 8.2 a range of medium alkalinity.

FERTILIZERS FOR THE GARDEN

In addition to organic matter, vegetables need a soil high in fertility to develop well and to have succulence and good quality. Land for gardening, therefore, requires a generous program of soil fertilization.

Plant food for a garden is supplied by: (1) manures, (2) commercial fertilizers.

Manures. In the earlier days of gardening, manures were a readily available form of fertilizer. In recent years, however, scarcity of this material has greatly reduced the available supply especially, for city and urban gardeners. It is necessary that manures be stored under cover to prevent leaching of valuable plant food. Nitrogen, an increasingly valuable element in these emergency times, is easily lost in the manure by leaching and hot fermentation. To reduce the loss of nitrogen by fermentation in the form of ammonia, 75 pounds of superphosphate, 18 per cent, should be mixed with each ton of manure as it is being composted or piled.

When manures are applied to the soil in a fresh condition, there is the least loss of plant food from leaching and fermentation. Manures in general should be applied early enough, possibly about 8 weeks before the planting season, to be rotted in the soil.

The rate of applying manure depends upon the kind and supply available, the kind of crops grown and the condition in which the manure enters the soil. At the rate of 8 to 12 tons per acre, the application on the home garden area will be about 100 to 150 pounds or three to five wheelbarrow loads per square rod (272 square feet). A small amount of manure on garden ground is better than none, for it acts as an inoculant and stimulant to the soil microorganisms as well as providing plant food and organic matter.

Under most conditions broadcasting is the best method of applying manure. On the farm a manure spreader can be used to advantage. Most manures are plowed or spaded under the soil so that the material is rotted in the soil before planting operations begin. Manure seldom is so finely rotted that it can be satisfactorily worked into the soil by disking. For some crops such as cucumbers, melons, and tomatoes, rotted manure is often applied in hills and thoroughly mixed with the soil of the hill rather than put in the bottom of the hole and covered with soil.

Table 2 shows the approximate average composition of fresh manures and the relative number of pounds of nitrogen, phosphoric acid, and potash contained in the crop.

Table 2. APPROXIMATE AVERAGE COMPOSITION OF FRESH MANURES.

Source	Water	Content per ton			Commercial value per ton*
		Nitrogen	Phosphoric acid P_2O_5	Potash K_2O	
	Per cent	*Pounds*	*Pounds*	*Pounds*	
Poultry	55	20.0	16.0	8.0	$5.00
Sheep	68	19.0	7.0	20.0	4.75
Horse	78	14.0	5.0	11.0	3.30
Swine	87	10.0	7.0	8.0	2.70
Cow	86	12.0	3.0	9.0	2.67
Mixed	80	10.0	5.0	10.0	2.60

* Based on average prices of commercial fertilizers at time of publication.

Poultry manure is the most concentrated of farm manures. One hundred hens in a year will produce 4 tons of droppings, exclusive of the bedding material, which may be straw, peat moss, sawdust, or shavings. It is advisable when composting poultry manure to add 2 pounds of superphosphate, 18 per cent, to droppings of 100 hens per day. This prevents loss of nitrogen in the form of ammonia, and adds phosphoric acid.

Because of the concentration of chicken manure more than usual care is necessary in applying it to garden plants. The application should be held to approximately 25 to 30 pounds to a square rod, or 2 to 3 tons per acre. As with other manures, it is advisable to apply

poultry manure and bedding early enough for it to be decomposed before planting seed or setting out plants.

Sheep manure is seldom obtained in a fresh, unleached state, but when dried and ground it is found available at retail dealers. The analysis of such manure is approximately 1.25 per cent nitrogen, 1 per cent phosphoric acid, and 1 per cent potash.

The value of stable manure is further discussed in the paragraphs on mulching the soil.

Turkey feathers make good fertilizer, and where available within reasonable hauling distance, can be used to good advantage on the garden soil. From experiments conducted by the Oregon Experiment Station, 2 to 5 tons of wet feathers were ample for good results and produced twice as much corn and half again as much fodder as an untreated plot.

The feathers heat readily in a pile and should, therefore, be applied to the soil as soon as possible from the turkey killing plant.

Wood products. There is very little available plant food in waste wood products of themselves but these materials are often used as bedding in barns and chicken houses. Such a mixture of manure and the bedding may be used to advantage in the garden.

An adequate supply of moisture is necessary to hasten decomposition of sawdust. Some nitrogen fertilizer applied with the sawdust will help it to rot more readily. Sawdust soaked with urine from the barn will decompose without robbing the soil of available nitrogen.

COMMERCIAL FERTILIZERS

Commercial fertilizers are often used in the garden to supplement plant food and other organic material contained in manure. In no way, however, do they substitute for manures in the matter of contributing organic matter.

Vegetable growers are fairly liberal users of commercial fertilizers, for the gardening soil must be above the ordinary in fertility. Under the present emergency conditions restricting the supply of certain commercial fertilizers, it is especially important that they be applied in an economical and efficient manner.

Fertilizers are found on the market as: (1) simples, (2) materials containing two of the major plant food elements, (3) complete fertilizers.

Simples are individual materials that are used alone or mixed to form a complete fertilizer. The word "material" indicates the actual product on the market supplying the plant food element; thus *sulphate of ammonia* is a commonly used material supplying nitro-

gen; *superphosphate,* a widely used material for furnishing phosphoric acid, and *muriate of potash* and *sulphate of potash* are common materials supplying potash. Sulphate of ammonia, superphosphate and muriate of potash are "simples." Mixed together, these three would make a complete fertilizer.

Ammoniated phosphate and bone meal are examples of materials containing two of the major plant food elements, for both of these contain nitrogen and phosphoric acid but no potash.

A complete fertilizer is a mixture of compounds containing the major plant food elements, nitrogen, phosphoric acid, and potash, respectively, and is designated and known by its analysis or grade, which by a series of numbers states the percentage composition of the fertilizer. In this series of numbers the first always indicates the percentage of nitrogen, the second the percentage of phosphoric acid, and the third the percentage of potash. Thus a 4-12-4 complete fertilizer has an analysis of 4 per cent nitrogen, 12 per cent phosphoric acid, and 4 per cent potash. One per cent of plant food is 1 pound of nitrogen or phosphoric acid or potash for each 100 pounds of material. Thus a 100-pound sack of 4-12-4 complete fertilizer contains 4 pounds of nitrogen, 12 pounds of phosphoric acid, and 4 pounds of potash.

Mixed or complete fertilizers are sold under specific names or brands. Some companies sell under the same trade names several different kinds of complete fertilizers varying in the analysis or grade. Oregon laws require that the content of the fertilizer bag must be stated on the label, designating the percentages of nitrogen, phosphoric acid, and potash.

Recent rulings by the federal government have reduced the number of approved grades or analyses of complete fertilizers for sale in the state of Oregon. At the present time the approved analyses include 4-12-4, 3-10-10, 5-6-8, 9-4-6, 3-10-20, 0-12-20, 4-24-0, 4-24-4, and 6-30-0. These analyses may be used only in commercial gardens. War Production Board order M-231 limits the sale of commercial fertilizers for Victory Gardens* to a complete fertilizer having a grade or analysis of 3-8-7, and this will be sold in the state as a "Victory Garden fertilizer."

Soils vary greatly in their supply of available plant food. Some soils have ample supplies of all plant foods; others may require only one or two. Commercial fertilizers are used to make up soil deficiencies. For most home gardens, therefore, the safest approach is to apply ample amounts of all major plant food elements. This is

* A "Victory Garden" is defined as any garden planted primarily for noncommercial production of vegetables and small fruits.

the reason for the popularity of complete fertilizers for use on home gardens.

The use of commercial fertilizers by the gardener involves consideration of:

(1) What fertilizer shall be used?
(2) What amount shall be applied?
(3) How and when shall it be distributed?

Value and use of nitrogen. Of the elements commonly supplied by commercial fertilizers, nitrogen has the most pronounced effect in encouraging the development of leafy growth of the plant and in imparting a dark green color to the leaves. It tends to produce succulence, a quality of considerable importance in most vegetables. Of the three major elements, nitrogen is more likely to be a limiting factor in crop growth than phosphorus or potash. Sometimes an extravagant supply of nitrogen will cause too much leafiness of plants, as is quite frequently seen in excessive tomato foliage or large, soft lettuce heads.

Table 3. QUANTITIES OF PLANT FOOD IN THE COMPOSITION OF AVERAGE YIELDS OF VEGETABLE CROPS

Crop	Part of plant	Yield per acre	Plant food content			
			Water	Nitrogen	Phosphoric acid	Potash
			Per cent	*Pounds*	*Pounds*	*Pounds*
Asparagus	Young shoots	3 tons	85	21	6	15
Rhubarb	Leaves and stems	10 tons	85	80	24	170
Snap beans	Leaves, pods	6 tons	85	90	21	96
Beets	Roots	6 tons	85	31	12	63
Cabbage	Heads	10 tons	90	60	20	80
Cauliflower	Heads	300 crates	90	57	25	86
Carrots	Roots	10 tons	85	46	26	106
Celery	Leaves and stalks	500 half-crates	84	70	50	187
Corn, sweet	Cobs and kernels	3 tons	75	45	19	36
Cucumbers	Fruit and vines	5 tons	95	30	14	80
Lettuce	Heads	200 crates	94	30	12	45
Onion	Bulbs	300 sacks	86	79	31	75
Parsnip	Roots	10 tons	80	44	40	130
Peas	Green peas	3 tons	85	69	18	27
Pumpkin	Flesh, vines, seeds	10 tons	90	58	17	83
Muskmelons	Fruit	200 crates	90	35	8	60
Spinach	Leaves, stems	6 tons	92	60	18	30
Tomato	Fruit, leaves, stalks	6 tons	92	102	32	150

Sulphate of ammonia and nitrate of soda are important nitrogen fertilizers. They are quickly soluble in water or in the soil solution and act as a rapid stimulant to vegetable plants. When mixed with water either one becomes a simple booster solution. (See page 17.)

The nitrogen from organic nitrogen sources, such as blood, fish, or tankage, is not so readily available as that from the inorganic

sources. These materials are important nitrogen-carrying fertilizers, however, and are useful in growing many vegetables in the garden, particularly those that have a long growing season.

In general the efficiency of nitrogen is increased where materials supplying phosphoric acid and potash are used with it.

Besides their inclusion in a number of complete fertilizers, nitrogen materials are useful for side placement to rows of plants after these can readily be seen. If, for example, such a fertilizer as sulphate of ammonia or nitrate of soda is used just before or during a rain, the material will have a rapid effect on the growth of the plants. (See methods of placement, page 14.)

Phosphoric acid. This element is valuable in stimulating root growth and inducing blossom formation and may sometimes be the limiting factor in a good growth of vegetables. Phosphoric acid is helpful in stimulating an early maturity of some vegetables, such as head lettuce, cabbage, sweet corn, and tomatoes. It is considered useful in strengthening the stems of plants and increasing resistance to freezing. It is thought also to counteract the effects of overstimulation of foliage due to an excess of nitrogen. There seems to be an increase in the efficiency of phosphoric acid when used in combination with nitrogen.

Garden soils sent in to the Soils Department for examination frequently register a low content of phosphoric acid. This can be remedied by using a complete fertilizer having a high content of phosphoric acid in it.

When manure is being composted, superphosphate should be added at the rate of 75 pounds per ton of manure to prevent loss of nitrogen in the form of ammonia.

It is important to distinguish between the 18 to 20, 32, or 45 per cent grades of phosphate. So-called treble-phosphate contains almost three times as much phosphoric acid as does the regular 18 per cent superphosphate, but the latter contains about 50 per cent landplaster or calcium sulphate, which would provide an ample supply of sulphur.

Potash. This major plant food is especially useful in the growing of roots and fruiting crops and is found abundantly in leafy vegetables. When present in plentiful amounts in the soil it seems to influence peas to be more tender and decrease physiological disturbances, such as leaf-scald, tip-burn, and spotting. It is useful in improving the keeping qualities of cabbage, celery, and other vegetables. Table 3 shows the quantities of plant food removed from the soil by various vegetable crops. Ordinarily, however, potash is not deficient in Oregon soils. It is important to note that quite a high

amount of potash is removed by such crops as cabbage, cauliflower, carrots, celery, cucumber, lettuce, onions, pumpkins, and tomatoes.

Sulphur. An essential plant food for most vegetables, particularly legumes, is sulphur. Unless sulphur is provided in one or another of the commercial fertilizers such as superphosphate, ammonium sulphate, or sulphate of potash it should be applied in the form of land plaster. Applications should be at the rate of 100 to 150 pounds of land plaster per acre, or from two-thirds of a pound to a full pound per square rod for western Oregon. For eastern Oregon the rate should be from 50 to 100 pounds per acre.

Minor or trace elements. It has recently become more apparent that in addition to the major plant food elements, nitrogen, phosphoric acid, and potash, minute quantities of several chemical elements have important effects on the health and growth of plants. As these are required by plants in exceedingly small amounts, they have become known in the fertilizer trade as trace or minor elements. Among them are boron, manganese, zinc, copper, sulphur, and iodine, as well as others for which the need is not so well established. The possible functions of these minor elements and the responses of plants to their presence in the soil are discussed in Oregon Experiment Station Circular of Information 223.

The usefulness of boron as a means of controlling celery stem crack and beet canker is discussed in Circulars of Information 212 and 248, respectively.

Within recent years some of the complete fertilizers on the market have included small amounts of the minor elements.

Methods of placement. Where to place commercial fertilizer for the benefit of seeds and plants is as important a consideration as what and how much fertilizer to use. Seeds and plants may be injured by incorrect placement and there may be waste of material.

There are four common methods of applying commercial fertilizer to land for vegetables: (1) broadcasting before planting, (2) sowing fertilizer at the time of planting, (3) applying material in the hill before or at the time of planting, (4) row application after plants are up.

Method 1, broadcasting fertilizer over the garden area previous to planting, may be considered as a fundamental or general application of plant food to the garden as a whole. Broadcasting from 5 to 8 pounds of a complete fertilizer per square rod (272 sq. ft.) would be a normal application equal to about 500 to 1,000 pounds per acre. This should be applied preferably several days before planting and incorporated with the soil by spading or plowing it under. Such an

application may or may not be supplemented later by a side dressing, depending on the ensuing crop growth. Broadcasting requires more fertilizer per square rod or acre than other methods.

Method 2, sowing fertilizer at the time of planting, is increasing in commercial use for such crops as snap beans, peas, and sweet corn and is equally effective in the home garden. In this method the fertilizer is placed 2 inches to the side of the seed row and slightly below the level of the seed. Special equipment is now available on commercial seeders for placement of fertilizer in this manner. In the home garden the same practice of application may be carried out except that the fertilizer is applied by hand in a furrow, made by a hoe, 2 inches from the seed row.

The fertilizer should not be placed directly over or in direct contact with the seed.

If fertilizer is placed in the same furrow as the seed it should be below and not above the seed. In that case there should be an inch or so of fertilizer-free soil separating the fertilizer and the seed. In carrying out this operation the gardener would open with a hoe a furrow about 3 to 4 inches deep, at the bottom of which the fertilizer is placed and covered with an inch or so of soil. The seed can then be planted on top of the fertilizer-free soil and covered the desired depth. If very small seed is to be planted the furrow need not be as deep as that indicated.

This method of using fertilizer should be carried out with the particular caution that sufficient soil must separate the seed and fertilizer material so that no fertilizer comes in contact with the seed.

Method 3, applying material in the hill before or at time of planting, is often used in fertilizing land for plants grown at wider distances between hills or plants in rows as in the culture of cantaloupes, cucumbers, squash, and tomatoes. The fertilizer is well mixed with the soil at the check marks of hills or plants just before sowing seed or transplanting plants, or it can be mixed with the soil several days before doing this operation. The important feature of this method is the thorough incorporation or mixing of the fertilizer, 1 to 2 ounces, with the soil of the hill.

Sometimes the fertilizer may be placed as a spot application at the time of planting seeds by placing 1 to 2 ounces of the fertilizer in a band on each side of the hill of seed and separated from it by at least 1 to 2 inches of fertilizer-free soil and in a depth zone 1 inch or more below the seed level.

In the case of transplanting plants such as the tomato, the fertilizer should be thoroughly mixed with the soil before the plant is

set in the hill. Sometimes the fertilizer is applied by being spotted in a band around or to one side of the plants, the inside of the band being at least 2 inches from the stem of the plant. The fertilizer should be below the surface of the soil and should be separated by at least 1 to 2 inches of fertilizer-free soil from the roots of the transplanted plants.

In **Method 4**, row application after plants are up, the amounts applied are usually about the same as for Method 2. An application is made slightly below the surface of the soil and about 2 inches from the side of the rows. The bands of fertilizer are usually about 2 inches wide. Either or both sides of the row may be fertilized. If these applications are being made during the spring of the year, it is desirable to make such applications during a rain or before an irrigation.

One ounce of the average complete fertilizer equals 1 rounded tablespoonful; 2 ounces equal a short ½ cupful. Two ounces or so should be sufficient for the average hill or individual plant application.

In making row applications the usual amount of fertilizer applied would be from 1 to 1½ pounds to each 100 linear feet of row, applied 1½ to 2 inches away from it. No fertilizer should be allowed to come in contact with leaves or stems of the plants in making the side applications. If possible, row applications should be made just before or during a rain so that the fertilizer will not be disturbed by any cultivating tool before it gets into the soil solution. Under other conditions the fertilizer can be lightly hoed into the soil, followed by an application of water that will not disturb the fertilizer or pack the soil.

BOOSTER OR STARTER SOLUTIONS

The use of booster or starter solutions has now become an established practice with many commercial vegetable growers and it may have an important place in home gardening operations.

Any commercial plant food material that is highly soluble in water may constitute a booster or starter solution when mixed with water. Such solutions are used mainly in the growing of young plants and the setting out of plants in the garden and field.

Value of booster solutions. The main benefit of a booster solution is to provide the plant with immediately available plant food, and in this way to stimulate leaf and root growth, quicker pick-up after transplanting, and earlier maturity of the crop. The solutions are particularly applicable in growing young plants of tomato, celery,

pepper, melon, eggplant, cabbage, cauliflower, lettuce, and other transplanted plants.

In the earlier days of plant growing, gardeners and greenhouse men put barnyard manure into a barrel and made a mild liquid solution having a light amber or weak tea color. Such material is still useful in plant growth. Manure water is particularly beneficial for leafy vegetables, but it is comparatively low in phosphoric acid.

Formulas for booster solutions. A number of different formulas may be made up to constitute a starter solution. Any of the following can be used to good advantage:

(1) 20 ounces of 11-48-0 ammoniated phosphate
10 ounces of sulphate of potash
50 gallons of water

Double this amount in 50 gallons of water may be used without injury to plants.

(2) 1 ounce of such commercial fertilizers as 4-12-4, preferably containing chemical nitrogen, may be used with each gallon of water

(3) 16 ounces of sulphate of ammonia
12 ounces of treble phosphate
4 ounces of muriate of potash
¾ ounce to 1 ounce of this formula may be used per gallon of water.

(4) 1 to 2 ounces of "Victory Garden" fertilizer, 3-8-7, per gallon of water

The simplest booster solution would be sulphate of ammonia, 1 ounce, mixed with 1 gallon of water. This solution would boost the foliage growth of the vegetable plant but would not have the stimulating influence on the root system provided by the complete fertilizers.

It is important that the chemical fertilizers used by the gardener in making up solutions (1) and (3) be carefully weighed. When guesses are made plants may be damaged by application of too strong solutions.

Booster solutions are not usually made up from organic sources of plant food, such as bone meal, tankage, or blood. Rapid effects from such applications are not to be expected, as these materials are only partly soluble in water.

Starter solutions are used primarily to wet down tomato and other transplants several hours before they are set in the field. In applying the solution to the young plants growing in a flat or cold frame it should be on the soil about the plants and not sprinkled on

the plants themselves. The thorough wetting of the soil will give the plants moist soil to be taken to the garden, and the plants will therefore cut out more readily and with less root disturbance. It will also provide available plant food in the ball of soil that is cut out in the process of separating plants from the flats or frames. Plants grown in individual containers are particularly benefited by a booster solution as the entire mass of soil about the plant will absorb the solution and take it to the garden.

Booster solutions are also applied by pouring ½ to 1 pint of the solution about the roots of plants as they are being set out in the garden and field. This solution will help in getting the plants more quickly established in the new location. Particularly is this true if there is an ample amount of phosphorus in the solution, for this plant food stimulates the development of roots.

A similar treatment of plants can be given in the summer transplanting of cabbage, cauliflower, broccoli, celery, and other plants. Instead of having plain water in the barrel or cylinder carried on the transplanter, either machine or hand, one can use any one of the starter solutions mentioned.

SOIL PREPARATION

Many vegetables are grown by sowing small seeds that require a fine seedbed for good germination and a uniform stand of plants. Consequently, soil preparation in a garden requires a greater amount of work, preliminary to seeding, than is customary with general farm crops. The time of plowing or digging is particularly important with certain heavy soils in that the work should be done when the soil is in a suitable condition and not when it is wet. Too early stirring of such a soil increases the difficulty of fining it and preparing a seedbed. The urge in the spring that comes to a gardener to turn over the ground should be restrained until the soil is in proper condition, when it will crumble readily after being plowed or spaded. No soil should be worked when it is wet and sticky; otherwise the granular structure of the soil may be destroyed for the whole season so that it becomes hard and cloddy. This precaution is not so necessary with light soils which may often be prepared quite early in the spring and planted to early vegetables as soon as the land is prepared.

It is important, too, that a garden soil be well prepared so that the vegetable plant may develop a good root system that is fundamental to a vigorous top growth.

No amount of soil stirring or after-cultivation following planting will take the place of good preparation. It is particularly neces-

sary in growing a dry-land garden that the soil be well fitted to hold moisture during the dry season.

The common method of soil preparation consists of: (1) broadcasting manure, (2) plowing or spading, (3) disking, (4) harrowing, (5) fining, smoothing, or raking the soil. Manure is spread before plowing or spading, particularly if it is unrotted. In some cases, very fine rotted manure may be applied to plowed land and mixed with the soil by disking but, as a general rule, manure should be turned under the soil. Sod or strawy manure should be plowed under in the fall or sufficiently early in the spring to allow for rotting before planting time.

If there is no cover crop on a heavy soil it is preferable to fall-plow the land and allow it to lie in a rough state through the winter in order to make it possible to work the ground earlier in the spring than otherwise.

In the early months of the year, when there is usually considerable moisture in the soil and possible frequent rains, seed treatment is advisable for some vegetable seeds. Such treatment, designed to keep the seeds from rotting and to improve the per cent of germination, is commonly given to seed planted outdoors such as spinach, beet, pea, sweet corn, and sometimes bean, melon, cucumber, and squash. The treatment consists of mixing with the seed either yellow copper oxide (Cuprocide), a mercurial dust (Semesan), Spergon, zinc oxide, or other material, according to the kind of seed being used.

CULTIVATION

Cultivation in the garden is the operation of stirring the soil between the rows and plants, having for its chief objectives the elimination of weeds and the establishment of a soil mulch to prevent loss of moisture.

Cultivation of soil in a garden should not be a habitual practice every week or so but rather carried out each time with a specific objective in mind, killing weeds or forming a mulch. Cultivation is often practiced to excess through frequent, unnecessary soil stirring, which is not only an added expense in growing the crop but may destroy fine feeding roots as well as bring valuable soil moisture to the surface to be evaporated.

Soil stirring is useful in renewing a good soil mulch following a rain or an irrigation or in mixing side dressings of fertilizer with the soil. In dry weather, however, if there is no weed growth and a soil mulch is already present, soil stirring is not necessary and may be decidedly harmful.

Cultivation of garden soil should generally be shallow. Weed-cutting and mulch-forming tools should preferably be used rather than wide shovels or vertical spikes that may cultivate deeply, bring moist soil to the surface, and tear out feeding roots, three undesirable results of improper soil stirring.

Hoeing is an important and frequently necessary practice of cultivation. "Scuffle" and "open" hoes with blades somewhat parallel to the soil are useful in destroying weeds and forming a desirable shallow mulch. Deep hoeing is seldom beneficial. Most vegetable crops are level-cultivated and few are benefited by hilling.

Many early spring weeds may be destroyed just prior to the sowing of seed, if the land is allowed to stand a few days after final preparation before planting seed. All weeds are much more easily and quickly killed when small.

IRRIGATION

The benefits of being able to water the vegetable garden are well known to many gardeners. Most vegetable crops have a high water content and need a consistent supply of soil moisture to produce good yields of high quality. These crops can use to good advantage from 2 to 3 inches of rainfall or its equivalent in irrigation water per month.

Rainfall in western Oregon is inconsistent and inadequate during the best growing months of the year, and in times of drouth the dry-land garden is severely handicapped. Lack of soil moisture then becomes a limiting factor in production.

Where water is available, seeds can be sowed in moist soil throughout the season, thus keeping the garden continuously cropped. Young plants can be transplanted to good advantage when there is moist soil. Supplementary applications of fertilizer can be made quickly available by the use of the watering system. Attacks of insects can often be thwarted, partly at least, when plants are growing steadily under irrigation. Some gardeners have stated their irrigation equipment was well worth the investment if for nothing but its usefulness in providing water for the growing of soil-improvement crops such as legumes, not to mention the stimulation of cash crops grown on the same land after the cover crop is turned under.

Farm home gardens will return good interest on an outlay for irrigation equipment, as is consistently demonstrated by commercial growers.

City and suburban gardeners often have the best opportunity to be able to maintain proper soil moisture in gardens provided water rates are not prohibitive in cost.

In the case of any garden the proper use and application of water is an important factor in making it of the greatest value to the vegetable plants. The important thing in watering a garden is to apply a sufficient amount of water, and no more, so that the soil about the root system is well supplied with moisture. In crops that are developing well this amount is from 1 to 3 inches of water for each application.

Whether water is distributed in furrows to the rows of plants or is sprinkled over the garden is usually determined by the source and pressure of water available.

Low-pressure water can be applied to good advantage by the furrow method, which consists of opening shallow furrows lengthwise one side of the rows. Furrow waterings apply the water fairly rapidly in the home garden and the root zone is well-moistened. In a garden that has a fairly steep slope in one direction, the water should be applied at as near right angles as possible to the slope to avoid unnecessary washing. Uneven garden ground that cannot be leveled for furrow irrigation is watered satisfactorily by sprinkling.

MULCHING

Putting a cover of some organic material on the soil during the growing season may have several advantages, including conservation of moisture, discouragement of weed growth, addition of plant food and a cushion for watering the soil and retarding evaporation. Strawy manure, straw, and peat moss are among materials used. A mulched garden, or at least part of it, may be especially valuable in an unirrigated garden, in which case the mulch tends to decrease the loss of moisture.

Mulches tend to reduce the packing of soil when water is applied from the hose or a sprinkler. The organic matter of the mulch forms a good cushion for receiving the water. Strawy manure has valuable plant food in it that is made available when the garden is watered.

Mulching materials are applied around individual plants, such as tomatoes, or between the rows of plants.

Sawdusts of various kinds are sometimes used as mulching material but they contain very little available plant food and decompose slowly.

SYMPHYLIDS

Garden soils are sometimes more or less unproductive because of the presence of a certain small, white, centipede-like animal called the symphylid. The adult symphylid is white, $\frac{1}{8}$ to $\frac{1}{4}$ inch in length, has six to twelve pairs of legs depending on age, no eyes, but two

prominent antennae or feelers that are kept constantly in motion as it moves about the soil. The mouth parts are of the chewing type. Symphylids are found in the lower parts of the soil where there is ample moisture at the roots of plants or near the soil surface where seeds are germinating in moist soil.

The gardener is first inclined to consider the poor germination of seed or the inferior stand or growth of plants as being caused by unfavorable soil conditions such as a "sour" soil or one lacking in fertility. In most cases, however, there is nothing wrong with the soil reaction or its normal content of plant food. Whenever the soil is neither strongly acid nor alkaline and is normally fertilized but seeds do not germinate well and plants grow poorly, one may suspect that symphylids are present. This theory is usually confirmed by careful soil examination.

The symphylids attack seeds and germinating rootlets. The seeds are injured to the extent that the stand of plants may be poor or sometimes a complete failure. If seeds survive and plants grow, their root systems may be attacked and the plants may be considerably dwarfed. While seeds of such vegetables as beans, beets, corn, and spinach are favorites of the symphylid, yet no vegetables are known to be entirely free of its attack.

Populations of symphylids vary considerably in a garden and from few to many may be found from one end of the row to the other. The method of distribution from one place to another is largely a transportation problem; that is, the symphylids are transported by soil or organic matter or tools from one part of the garden to another.

Thus far no control of symphylids is economically possible in the average garden. Thorough soil pulverizing will destroy many of the symphylids for they are found freely in clods of soil. This pest, which is one of the major pests of gardening soil in the western part of the state, is receiving continued studies at the Oregon Agricultural Experiment Station.

CROP GROUPINGS IN RELATION TO USE AND CONSERVATION OF SPACE IN THE GARDEN

Garden Soil Management demands consideration by the grower of the greatest utilization of the garden land that is available. A well planned garden, in which crops are properly grouped, will invariably conserve space and yield more vegetable produce than a garden that is unplanned or has no systematic crop groupings.

The following groupings of crops serve to show the gardener how crops fall into certain practical classes with relation to land use and planting seasons.

Crops Occupying Ground Part of Season and May Be Followed by Others

Bush bean	Early or late cauliflower	Early corn	Lettuce	Peas	Spinach
Beet		Kale	Mustard	Early potatoes	Turnip
Early cabbage	Carrot	Kohl-rabi	Green onion	Radish	Rutabaga

All of the crops in this group with the exception of late cauliflower, kale, and rutabaga can be grown as early crops and followed by later ones.

Crops that May Follow Others

Bush bean	Carrot	Kale	Radish	Broccoli	Cauliflower
Beet	Late corn	Lettuce	Late potato	Brussels sprouts	Turnip
Late cabbage	Celery	Mustard	Spinach		

Most of the crops in this list can follow early, half-season vegetables.

Crops Occupying the Ground All of the Growing Season

Perennial	*Annual*				
Asparagus	Pole beans	Eggplant	Parsley	Late potato	Winter squash
Rhubarb	Lima beans	Muskmelon	Parsnip	Pumpkin	Tomato
Artichoke	Swiss chard	Onion	Pepper	Salsify	Watermelon
	Cucumbers				

Perennial crops are set at one side in the garden. The long distance annuals occupy the soil from April or May to October.

Crops of Which Seed Can Be Sown Before Last Spring Frost

Pea	Lettuce	Turnip	Beet	Chard	Potato
Spinach	Onion	Kohl-rabi	Carrot	Radish	

With the exception of the potato, the plants listed above are able to withstand light frosts.

Crops of Which Plants Are Subject to Frost

Bean	Tomato	Squash	Eggplant	Melon
Sweet corn	Cucumber	Pepper	Pumpkin	

These warm-season annuals should not be seeded or transplanted till weather is consistently frost free.

Crops that Constitute a Good Fall and Early Winter Garden

Late beans	Late cabbage	Turnip	Chard	Parsnip	Chinese cabbage
Broccoli	Cauliflower	Rutabaga	Late beet	Salsify	
Brussels sprouts	Kale	Spinach	Carrot	Celeriac	Mustard
					Potato

Oregon Extension Bulletin 594 discusses the detailed culture of many of these useful vegetables that complete an important season of the gardening year.

CROPS GROWN FROM PLANTS HOMEGROWN OR BOUGHT

Early cabbage	Tomato	Late cabbage	Brussels sprouts	Celery
Early lettuce	Eggplant	Cauliflower		Melon
Pepper	Onion	Broccoli	Kale	

Plants in the first two columns on the left and celery and melon on the right are grown with artificial heat. Late celery and the members of the cabbage tribe are grown from plants in an open, unheated plant bed.

CROPS THAT CAN BE HARVESTED MORE THAN ONCE

Asparagus	Brussels sprouts	Pepper	Parsley	Bean	Cucumber
Rhubarb		Squash	Mustard	Pea	
Chard	Tomato	Melon	Sweet corn	Broccoli	

These are all "cut-and-come-again" vegetables with numerous, continuous harvestings.

CROPS THAT CAN BE STAKED TO SAVE SPACE

Pole bean	Tall pea	Tomato	Cucumber

In a small garden vertical training of these plants is important.

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