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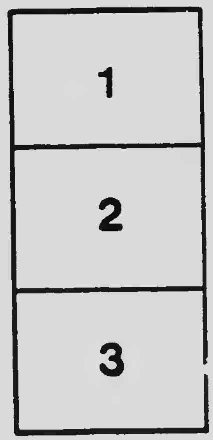

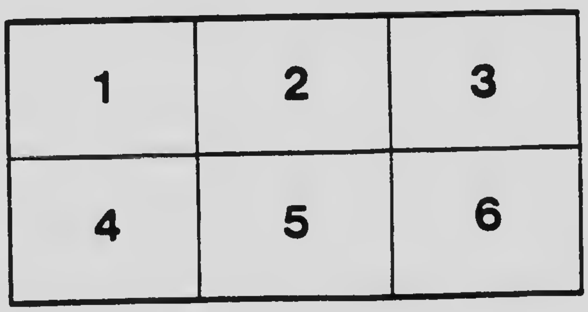

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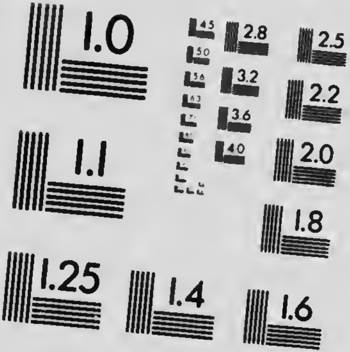

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DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

THE MANURING OF MARKET GARDEN CROPS

WITH SPECIAL REFERENCE TO THE USE OF FERTILIZERS

BY
FRANK T. SHUTT, M.A., D.Sc.
Dominion Chemist.
AND
B. LESLIE EMSLIE, C.D.A., F.C.S.
Supervisor, Investigational Work with Fertilizers.

BULLETIN No. 32
SECOND SERIES
(April, 1917)

Published by authority of the Hon. Martin Burrell, Minister of Agriculture, Ottawa.

DOMINION OF CANADA

DEPARTMENT OF AGRICULTURE

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CENTRAL EXPERIMENTAL FARM,
OTTAWA, ONT., April 25, 1917.

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to transmit herewith Second Series Bulletin No. 32 of the Experimental Farms, entitled "The Manuring of Market Garden Crops," and prepared by the Dominion Chemist, Dr. Frank T. Shutt, and Mr. B. Leslie Emslie.

The information contained in this bulletin is such as has been and is in great demand by our correspondents and visitors The bulletin will, therefore, in my opinion, be a most useful one both at the present time and for many years to come, and I would recommend its publication forthwith.

I have the honour to be, sir,

Your obedient servant,

J. H. GRISDALE,

Director, Dominion Experimental Farms.

19861—1½

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THE MANURING OF MARKET GARDEN CROPS

WITH SPECIAL REFERENCE TO THE USE OF FERTILIZERS

BY

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Supervisor, Investigational Work with Fertilizers.

FOREWORD.

Market-gardening, or the growing of vegetables and small fruits, is a specialized and important branch of agriculture. It is the superlative expression of "intensive farming" the successful pursuit of which demands intelligence, skill, business acumen, and, perhaps, above all a knowledge of soils, manures, and fertilizers, the factors which control in a very large measure the quantity and quality of the produce.

The primary object of the market gardener is to secure a maximum yield of first-quality produce from the land at his disposal, which is frequently of a very limited area. Of equal importance in the production of certain crops is the attainment of early maturity, which permits the marketing of the crop at a time when the particular commodity is comparatively scarce and consequently commands a high price. "The early bird gets the worm" is a proverb particularly appropriate in its application here.

It is not intended that this should form a treatise on vegetable and fruit-growing, but a simple and brief statement of certain important matters related to the industry, a discussion of which may assist the market gardener in the successful and profitable pursuit of his calling.

Quality in Vegetables.

Although vegetables have a distinct food value, they do not primarily find a place in the diet of the majority by reason of their sustaining qualities. It is rather their wholesomeness and palatability and the fact that their use allows a pleasing, economic and thoroughly rational variety to the diet that a prominent place on the menu is accorded them,and especially on that of the chief meal of the day. Quality ranks in importance with earliness and yield; it is the factor that largely determines the commercial as well as the culinary value of the products. Especially is it of importance if the market gardener seeks to establish a reputation and a steady, profitable market for his vegetables, as is accomplished to-day by the dairyman and the poultryman for their produce. Quality in vegetables implies succulence, crispness, good flavour and absence of woody fibre (or stringiness), pungency, and bitterness. Thus, in early beets and turnips, to be palatable, there must be no development of woody fibre; radishes must be crisp and free from pungency; lettuce must be tender with no suspicion of bitterness.

How is quality obtained apart from that inherent to and naturally governed by the variety? The answer is, by a quick and uninterrupted growth. The development of the crop must be rapid and continuous. Apparently, the next question to be answered is, what are the factors, the conditions, that control this rapid growth? Briefly, they are favourable climatic conditions (warmth, sunshine, rain) an agreeable, suitable soil and an abundance, indeed an excess, of available plant-food in the soil ready at all times, when conditions of growth are favourable, to be utilized.

The recent introduction of overhead irrigation systems enables the market gardener to augment the soil's moisture supply in times of drought or insufficient rainfall. By such means he has the opportunity not only to satisfy the crop's moisture requirements but also to increase the availability of its food supply, since to be assimilable the soil plant food must be in solution. In green-house work all these factors, excepting sunshine, may be controlled.

The Soil.

It is unnecessary to describe the manner in which soils have been formed by the ceaseless operation of natural constructive and destructive agencies. Fertile soils are composed chiefly of varying proportions of sand, clay, limestone and humus.

According to the predominating ingredients, soils are designated as *sandy, clayey, calcareous* or *peaty.* Strictly defined, a loam is a soil containing sand and clay in such proportions that the product has neither the extreme porosity of sand nor the tenacity and imperviousness of clay while possessing in a sufficient degree the qualities or characteristics of both. Nevertheless, the value of humus as an essential element of all loams must not be overlooked; it is this constituent which imparts, probably above all others, that "loamy" quality possessed by soils of the highest degree of productiveness. A loam or sandy loam is the ideal soil for market-gardening.

The soil must be well drained to permit the free circulation of air and moisture and, at the same time, must be liberally supplied with humus, to ensure the retention of sufficient moisture for plant requirements. A water-logged soil is always a cold one, as the sun's rays, instead of transmitting warmth to such a soil, are utilized in evaporating its superfluous moisture.

The maintenance of the humus supply in the soil is important in all branches of agriculture, but particularly so in that of market-gardening. Humus not only fulfils the mechanical function of rendering soils porous and more retentive of moisture, but furnishes also the essential medium for the activities of the bacteria, so useful in rendering available plant food in the soil. Further, it represents the chief natural source of the soil's nitrogen supply.

BARNYARD MANURE.

Necessity for Manure.

The importance of manure in market gardening can scarcely be over-estimated. Stable manure has been and probably always will be the main stand-by of the market-gardener. Its value is not alone due to its fertilizing properties—though these are not inconsiderable—but also to the fact that it supplies humus-forming material, without which the soil cannot become an ideal medium for the growth of crops. Very liberal manuring is necessary in this specialized branch of agriculture, in order to maintain an adequate humus supply. Cultivation, or frequent stirring of the soil, promotes the oxidation and decomposition of organic matter and thus depletes the humus. Consequently, in market-gardening, where cultivation is essentially thorough and crops frequent, the rate of humus depletion would be exceedingly rapid were insufficient means employed for its maintenance.

It is possible, of course, to apply excessive quantities of manure, which, besides being wasteful, would be inimical to crop growth, but such a possibility is remote in market-gardening practice, where the frequency of cropping entails a heavy draft on the available plant food.

Nature and Composition of Manure.

No farm product is so variable as manure, the composition and value of which depend on a great many factors. Among these are the kind, age, function and food of the animal producing it, the quantity and nature of the litter employed, and, last but not least, the care taken in its production and preservation.

The analysis of a large number of samples of fresh horse and cow manure, from animals well fed and bedded with sufficient straw to hold all the liquid excreta, gives the following average figures per ton: Nitrogen 10 pounds, Phosphoric acid 5 pounds, Potash 10 pounds.

The following table states in approximate terms the relative proportions of solid (dung) and liquid (urine) excreta and bedding found in fairly well made manures of the more common farm animals. It also gives the amounts of nitrogen, phosphoric acid and potash in these components. The data express percentages and pounds per ton:

APPROXIMATE AVERAGE COMPOSITION OF MANURES (FRESH) FROM VARIOUS ANIMALS.

Kind of Animal.	Relative Proportions of Solid Excrement, Liquid Excrement and Bedding in Manure.	Pounds per Ton.	Nitrogen.		Phosphoric Acid.		Potash.	
			p. c.	lbs.	p. c.	lbs.	p. c.	lbs.
Horse	Solid excrement	1,200	0·55	6·60	0·30	3·60	0·40	4·80
	Liquid " (urine)	300	1·35	4·05	trace		1·25	3·75
	Bedding material	500	0·50	2·50	0·15	0·75	0·60	3·00
	Total mixture	2,000	0·66	13·15	0·22	4·35	0·58	11·55
Cow	Solid excrement	1,260	0·40	5·04	0·20	2·52	0·10	1·26
	Liquid " (urine)	540	1·00	5·40	trace		1·35	7·29
	Bedding material	200	0·50	1·00	0·15	0·30	0·60	1·20
	Total mixture	2,000	0·57	11·44	0·14	2·82	0·49	9·75
Pig	Solid excrement	990	0·55	5·44	0·50	4·95	0·40	3·96
	Liquid " (urine)	660	0·40	2·64	0·10	0·66	0·45	2·97
	Bedding material	350	0·50	1·75	0·15	0·42	0·60	2·10
	Total mixture	2,000	0·49	9·83	0·30	6·03	0·45	9·03
Sheep	Solid excrement	1,206	0·75	9·04	0·50	6·03	0·45	5·43
	Liquid " (urine)	594	1·35	8·02	0·05	0·30	2·10	12·47
	Bedding material	200	0·50	1·00	0·15	0·30	0·60	1·20
	Total mixture	2,000	0·90	18·06	0·33	6·63	0·95	19·10
Poultry	Solid excrement	1,900	1·00	19·00	0·80	15·20	0·40	7·[illegible]
	Bedding material	100	0·50	0·50	0·15	0·15	0·60	0·60
	Total mixture	2,000	0·97	19·50	0·77	15·35	0·41	8·20

A study of this table will reveal many important facts regarding manures; we desire here merely to emphasize one or two of the more valuable lessons that may be drawn from the data: First, that the liquid portion (urine) is much richer in nitrogen and potash than the solid excreta (dung), weight for weight. Second, more than one-half of the nitrogen and at least three-fourths of the potash excreted by the cow —the chief manure-producing farm animal—are to be found in the urine. The fact that these constitutents are present in the urine in a soluble and practically immediately available form adds greatly to their value. Pound for pound, nitrogen and potash in the liquid portion of manure are worth much more than those in the solid excreta.

For the ordinary type of market garden soil, partially rotted, "short" manure is usually better than fresh, "long" manure. If it is necessary to hold manure for any considerable length of time before its application to the soil, the heap should be kept *compact and moist and protected from leaching rains.*

The specialized nature of the market gardener's operations precludes, as a rule, the possibility of producing any appreciable quantity of stable manure on his own premises, and he is, therefore, dependent largely on stock yards and city stables for the greater part of his manure supply. Although the production of the manure he uses is beyond his control, it is none the less necessary that the market gardener should be familiar with the factors which regulate its value.

Losses from manure occur chiefly through fermentation and leaching. If piled in a loose heap, fermentation (due to the free access of oxygen) is rapid and serious loss of nitrogen, in the form of gases, results. Horse manure, being of looser texture and containing a larger proportion of undigested food, ferments more readily than cow manure. To reduce the danger of excessive fermentation, *the manure heap ought to be kept firmly packed and reasonably moist.*

If manure, in rotting, becomes very hot, it is desirable that the heap should be occasionally turned, in order to control and check excessive heating which not only destroys organic matter and dissipates nitrogen, but ultimately leads to moulding in the interior of the heap—a sign of serious deterioration.

Loss through leaching occurs when the manure heap is exposed to the action of heavy rains, or, if purchased from stock yards or large stables, when the water hose is turned on it, after it has been loaded on the railway cars.

When we consider that more than one-half the nitrogen and at least three-fourths of the potash of manure is contained in the liquid portion (urine) the seriousness of loss by leaching will be readily appreciated.

Moreover, the nitrogen in the solid excrement, which has resisted the processes of digestion, is in an insoluble form and becomes only slowly available in the soil, whereas the constituents of fertility in the liquid, being already in solution, are immediately available.

At the present time the potash contained in manure represents the almost exclusive source of that ingredient for the market gardener, so that careful conservation of the liquid manure is now particularly important.*

The Influence of Manure in the Soil.

The various beneficial influences which manure exerts may be stated as *chemical, physical and biological.*

Chemical Influences of Manure.

These are due to the amounts of nitrogen, phosphoric acid and potash present in the manure and which are liberated in the subsequent decomposition of the manure within the soil in forms at once assimilable by crops.

Were its value dependent alone on its chemical properties, this could be determined in the same manner as that of the ordinary commercial fertilizer, by finding the amounts of nitrogen, phosphoric acid and potash present and assigning to each a certain price per pound. Such a valuation, however, would disregard other, and perhaps equally, important properties of manure.

* Wood ashes as a valuable source of potash are treated of on page 21.

Physical Influences of Manure.

Manure improves the physical character of both "heavy" and "light" soils, rendering the former more porous and friable and thus assisting aeration and drainage and in many other ways creating more favourable conditions for the development of the plant's root system.

A light sandy soil is rendered more compact by manure and its water-holding capacity thereby vastly increased.

Undoubtedly, the decomposition of the manure in the soil (a process of fermentation) liberates a considerable amount of heat, and thus it is that during the early weeks of spring, germination and the growth of the young plant will be encouraged on manured land.

By liberal manuring a light sandy soil may be gradually converted into a productive loam and the darker colour which manure imparts will increase its heat-absorbing capacity.

Biological Influences of Manure.

Manure not only furnishes the essential medium (humus) for the development of soil bacteria, myriads of which, in every fertile soil, are actively engaged in breaking down organic matter and releasing therefrom the elements of fertility in forms which can be assimilated by plants, but is itself a source of these useful bacteria. This fact, doubtless, in a great measure explains the beneficial effect of manure on peat or muck soils. This type of soil although naturally largely composed of organic matter is often insufficiently supplied with bacterial life, owing to excessive acidity or other unfavourable conditions.

The Compost Heap.

In market gardening the compost heap finds an appropriate place and provides a means of profitably utilizing large quantities of vegetable refuse—cabbage leaves, turnip and beet tops, etc.—which would otherwise go to waste. If these are composted with a little manure and good loam a valuable soil dressing may thus be produced at a very small cost. If a deposit of muck or peat, or of pond or river mud, is on or near the farm, these materials can be largely used to good advantage in the heap. Similarly, old sods, the cleaning of ditches, dead leaves, road scrapings and loam can all be utilized to good effect. The general plan, but one which need not be adhered to too closely, is to build up the heap in alternate layers of, say, six inches in depth of vegetable refuse and manure and good soil, peat or muck, covering the whole with a few inches of good soil or muck when the heap has reached a convenient height, say four or five feet. It is important that the heap should be kept moist in order that the processes of decay may proceed properly, but it should not be so wet as to cause drainage from the heap.

If manure is not available a sprinkling of wood ashes or lime may be made over the layer of muck or other refuse.

Green Manuring.

The growing and ploughing-in of a cover-crop furnishes a valuable means of supplementing the manure supply where the latter is scarce, but it is more adapted to "extensive" than to "intensive" agriculture and, therefore, cannot be fully taken advantage of by the average market gardener.

Legumes, such as clover and vetches, owe their popularity as cover-crops to the peculiar faculty, common to all plants of that family (*Leguminosae*) of deriving their nitrogen supply from the soil atmosphere by the aid of special bacteria which live in little nodules on their roots. Where its practice is possible, green-manuring with legumes commends itself as a means of enriching the soil in humus, as well as of supplying a large amount of valuable nitrogen, the most expensive ingredient in commercial fertilizers.

In view of the increasing difficulty, experienced by not a few market gardeners, in securing an adequate supply of good manure, the practice of devoting annually a certain area to the growth of a cover-crop deserves serious consideration. Such a method might be considered analogous to that which has been practised on the wheat areas of the West, where one-third of the land lies fallow, in rotation, each year to permit the accumulation of moisture which, there, is usually the limiting factor in crop production.

Of course, the adoption of this green-manuring system would depend upon the location and value of the land, as well as the cost and availablity of stable manure.

THE NATURE AND USE OF LIME AND ITS COMPOUNDS.

The application to the soil of quick lime or other lime compounds (slaked lime, ground limestone, etc.) is undertaken usually with one or more of the following objects in view: to effect an improvement in the tilth or texture of the soil; to supply lime for crop growth and for the liberation of plant food (chiefly potash) from insoluble soil compounds and to furnish a neutralizing base for acids in the soil—in other words, to correct sourness.

Generally, the latter is the most important object. Almost all cultivated crops thrive best on a soil which is either neutral or slightly alkaline. Further, such a condition favours the activities of the various bacterial organisms which, stage by stage, effect the formation of nitrates—the form in which plants assimilate nitrogen—from the supply of organic matter in the soil.

It is probably safe to assume that the majority of market garden soils, which have been manured heavily, would derive benefit from an application of lime in some form.

The statement has been made that a soil in which less than 0·5 per cent of available lime is present requires liming. The lime requirements, however, depend upon the character of the soil and the nature and solubility of the lime compounds therein.

Limestone, or Carbonate of Lime, also known as "mild" lime, is the chief naturally-occurring lime compound. In its finely crushed or ground condition it is a suitable, safe form for general application.

Marl (also known as shell marl), a deposit resulting from the accumulation and partial decomposition of fresh water shells on lake bottoms, though somewhat variable in composition, is essentially carbonate of lime. When dry, marl can be easily reduced to a fine powder which may be readily and uniformly distributed over the land; it constitutes one of the most useful forms of lime for agricultural purposes.

Quick-lime.—When limestone is burned carbonic acid gas is driven off and lime, known as "burned," "quick" or "caustic" lime, is obtained, 100 pounds of limestone (on the basis of 100 per cent purity) yielding 56 pounds of lime.

Slaked lime.—If water be added to quick-lime, "slaked" or "hydrated" lime results. Slaked lime, when exposed to the free action of air, gradually absorbs carbonic acid gas and thus reverts to carbonate of lime.

Both the burned (quick) lime and freshly slaked lime are strongly caustic and more or less vigorously attack the soil's organic matter, and depress bacterial activity. For this reason caution must be observed in their employment, which should be restricted to soils rich in humus and to heavy clay. On soils of the latter type they are particularly beneficial in improving the tilth by destroying the natural cohesiveness of the clay particles.

While most of the soil organisms unfavourable to crops (*e.g.* those producing club root in turnips and cabbage) are destroyed or held in check by an application of lime, an exception should be noted in the case of potato scab, which is encouraged by an excessive alkaline condition of the soil. For this reason it is not advisable to treat the land with lime, in any form, immediately before its occupation by a potato crop; the better plan is to apply the lime at a place in the rotation furthest removed from that crop, preferably in advance of one, such as the legumes, which will be most likely to derive benefit from the liming.

Gypsum.—Land plaster or gypsum, is a naturally-occurring sulphate of lime, of which there are many deposits in Canada. Although gypsum has a use in agriculture, it is valueless as a soil-acid neutralizer; it should never be applied with this object in view. Indeed, in this connection it may be pointed out that there is evidence that the continued use of gypsum tends to increase the acidity of the soil. Gypsum, however, when judiciously applied, at the rate of 300 to 800 pounds per acre, may prove beneficial by virtue of its influence in liberating potash from insoluble soil compounds. It is this valuable property that has made land plaster of particular service for clover and other legume crops.

Gas Lime.—This is a waste or by-product in the purification of illuminating gas, and may frequently be obtained from the city gas works for the cartage. It is quite variable in composition, but may be considered for practical purposes as a mixture of slaked lime, carbonate of lime, several sulphides of lime and certain tarry matter. The sulphur compounds present in the fresh gas lime, though imparting an insecticidal value, are distinctly injurious to growing vegetation, and hence the immediate incorporation with the soil of this material, as freshly drawn from the works, is not to be advised, excepting in cases where it is used specially for the destruction of certain noxious insects. Exposure to the air, as in small heaps in the field, will, however, in the course of two or three months convert these harmful sulphur compounds into harmless sulphate of lime. The fully exposed material, now essentially carbonate and sulphate of lime, may be spread and harrowed or lightly ploughed under. Thus used, it will be found a useful amendment for neutralizing soil acidity and indeed for all the purposes for which ground limestone and land plaster are employed. It has more particularly been used effectively on stiff clays and mucks; on these the application may be, say, five tons per acre, but on ordinary loams that are not exceedingly acid, the dressing may be in the neighbourhood of two tons per acre.

The Application of Lime Compounds.

Quick-lime.—Quick-lime, as purchased, is in hard lumps of greater or less size and as such is, as a consequence, not suitable for a uniform distribution over the soil. It must be slaked. This is most readily accomplished by placing the lime in small heaps, say of a bushel each, uniformly disposed over the field to be treated. Upon each heap pour a little water, about one-third the weight of the lime, so that the slaking may be gradual and a fine powder result; cover the heap with an inch or two of moist soil and allow to remain for two or three weeks, when the lime will be thoroughly slaked and fall into a fine powder. To facilitate distribution and avoid a certain unpleasantness in handling, it is well to mix the slaked lime with soil; the whole may then be fairly evenly spread with a shovel, and, if a damp day is chosen for the work, it may be accomplished without any great inconvenience.

Forty heaps of about 50 pounds, or about twenty-five heaps of 80 pounds each, is an application of approximately one ton per acre. On the heaviest soils the dressing may be two tons per acre, but on light and poor soils it should not exceed 1,000 pounds per acre.

There has been put on the market ground quick-lime, but it is not generally obtainable. Its distribution from a wagon box is rather unpleasant work, and if this form of lime is used it is desirable to apply it with a special lime-spreader or distributor or with a special attachment made for the seed or fertilizer drill.

Slaked Lime.—Slaked or hydrated lime may frequently be purchased; it is in the form of a powder and may be most conveniently, pleasantly and uniformly spread by employing a lime spreader or fertilizer drill, as mentioned in the preceding paragraph. It can, of course, be spread from a wagon box, but the operation is more or less disagreeable. If this method is adopted, the mixing of the slaked lime with a little fine soil is said to make the handling less unpleasant.

For these more caustic forms—quicklime and slaked lime—autumn is probably the best season for application, spreading on the ploughed land and immediately harrowing it in. The aim should be to incorporate the lime with the first three or four inches of soil. The tendency for all lime compounds is to be washed down by the rain, and, therefore, they should never be ploughed under.

Further, these more active forms of lime should never be applied in excessive amounts or harm to the soil will ensue from a too rapid dissipation of its humus and nitrogen. This caution is especially applicable to light loams. It is better to make light application frequently, say once in a rotation if necessary, than large applications at longer intervals. It is well to err on the side of too little than too much, and especially if the organic content of the soil cannot be constantly enriched

Ground Limestone.—The essential points to be remembered in the purchase of lime in this form (carbonate of lime) are composition and degree of fineness; poorer grades of limestone will contain from 65 per cent to 75 per cent carbonate of lime; the better qualities may have a carbonate of lime content of 95 per cent or over. An analysis as to its degree of purity should be demanded by the purchaser. If there is no guarantee as to fineness, an inspection or trial with sieves must suffice. The more coarsely the limestone has been ground the slower will be its action in the soil—and the longer will it remain an active agent in ameliorating the soil. Generally speaking, the coarser-ground material is the cheaper, as grinding, and especially to a fine powder, is a rather costly operation. If a quick, prompt action is desired, a material 75 per cent of which passes through a sieve with 100 meshes to the linear inch, will be found very satisfactory. Coarser ground limestones, however, can be successfully used—say 50 to 75 per cent passing through a 50 mesh sieve—all passing through a 10 mesh sieve—if immediate and, in a sense, quick, decisive action is not a desideratum.

The application may be from two to ten tons per acre, according to the character and the acidity of the soil and the degree of fineness of the material. Unlike quick and slaked lime, excess of ground limestone can do little or no harm and the same holds true of marl.

The application of ground limestone and marl offers no special difficulty or unpleasantness; a spreader may be used or the material distributed by shovel from a wagon. The materials may be applied at any season of the year and are specially suited, as has been stated, for light loams and soils generally that are poor in organic matter. As with lime, they should be applied to the surface and harrowed in, not ploughed under, or, in the case of meadows or pastures, merely spread on the surface.

Method of Testing for Acidity with Litmus Paper.

The usual test for acidity or sourness in a soil is blue litmus paper; if this is turned red the soil, we may conclude, is sour, is practically destitute of carbonate of lime, and will be benefited by liming or an application of marl or ground limestone.

Blue and red litmus paper may be purchased at any drug store. It is very cheap, and it is well to get the best quality obtainable. It can frequently be bought in small books containing twenty-five to fifty strips of the paper, each about one-half inch wide by two or three inches long, protected by a heavy paper or cardboard cover. These "books" are a very convenient and suitable form in which to have the test paper. They should be kept in a clean, dry, preferably wide-mouthed, well corked bottle. When tearing or cutting out a strip of the litmus paper for use, it is desirable to use a pair of forceps (or some other simple instrument, as scissors), as the paper is sensitive and the fingers may cause its reddening.

The following test is simple, and, if carefully carried out, reliable:

1. Take up, by means of a spade or trowel, a little of the surface soil from, say, half a dozen places on the area to be examined and mix well, using the trowel or a clean piece of board. Do not handle the soil. Take a small quantity (a few ounces) of the mixed soil, and, putting it in a clean cup or tumbler, pour on a little boiled water and stir with a clean piece of stick or spoon until the mass is of the consistency of a very thick paste. Into this "mud" press a piece of blue litmus paper by means of a small stick or the back of a knife, inserting the paper until one-half to two-thirds of its length is within the pasty mass. At the end of fifteen minutes carefully draw out the paper and note if the part that has been in contact with the wet soil has turned red. If so, the soil is acid.

The Elements of Fertility.

Of the ten or twelve essential elements of plant food but three tend to become deficient for crop requirements in the average soil. These are nitrogen, phosphoric acid (or phosphorus), and potash (or potassium).

A knowledge of the primary functions of these three elements will guide the market gardener in the intelligent application of manures and fertilizers for his crops.

Nitrogen more particularly promotes the growth of stem and leaf, and is, therefore, an important constituent of a fertilizer for cabbage, lettuce, and other leafy crops where a large leaf development is desired. A sufficiency of available nitrogen in the soil is indicated by the vigour of the crop; a deficiency of nitrogen is denoted by lack of vigour and a pale green or yellowish colour of the foliage.

Phosphoric Acid influences root development in the early stages and seed or fruit formation in the later stages of growth, which explains its importance for turnips and grain. It also promotes fruitfulness and early ripening, and is therefore important for all seed-bearing plants.

Potash is essential to the formation of carbohydrates which comprise the starches of potatoes, grains, etc., the sugar of fruits and vegetables and fibrous matter of plants.

Some of the earlier investigators in the field of agricultural chemistry believed that the kind and quantity of mineral matter found in the plant ash furnished an accurate indication of the mineral plant food requirements in each specified case and supplied a reliable basis for determining the fertilizer applications to the several crops. Subsequent investigations, however, proved the fallacy of this theory, and consequently it has been abandoned as a guide to rational fertilizing.

Further, in respect to their fertilizer or food requirements, it has been shown that crops vary in their power of assimilation. It does not necessarily follow that the presence of, say, nitrogen in large quantities in the plant composition necessarily indicates the need of a highly nitrogenous fertilizer. For instance, a 700-bushel (per acre) crop of turnips (roots) contains three times as much potash as a 200-bushel crop of potatoes (tubers), and yet turnips, if liberally manured, rarely derive benefit from a potash fertilizer, whereas potash is the fertilizer ingredient to which potatoes particularly respond.

Liebig, observing the comparatively small amount of phosphoric acid present in turnips, concluded that this crop required but little phosphoric acid in the fertilizer, but Lawes subsequently showed, by actual field experiments, that turnips, more than any other farm crop, responded to liberal applications of a phosphatic fertilizer.

The amounts of the plant food constituents contained in certain of the more important market garden crops are given in the following table:

Yield per Acre (Approximate Average.)	Nitrogen.	Phosphoric Acid.	Potash.
	lbs.	lbs.	lbs.
Beets (roots) 12 tons	60	24	120
Cabbage (heads) 15 tons	131	30	120
Carrots (roots) 12 tons	56	32	128
Corn, sweet (ears) 2 tons	18	8	12
Onions (bulbs) 300 bushels	42	16	39
Potatoes (tubers) 200 bushels	42	18	60
Tomatoes (fruit) 250 bushels	30	10	52
Turnips (roots) 15 tons	75	30	160
Wheat (grain) 20 bushels	24	10	6
" (straw) 2,000 pounds	10	3	12
" (grain and straw)	34	13	18

In compiling this table we have considered, in each case, only that part of the crop which is marketed, assuming that the residual parts will be returned to the soil.

A comparison of the quantities of plant food removed by some market garden crops with those removed by a crop of wheat will indicate the necessity for the liberal use of manures and fertilizers which the market gardener generally practises.

Reference has already been made to the fact that the quantity of each plant food element removed by the crop does not furnish us with an accurate estimate of its fertilizer requirements. In this connection, however, it should be observed that a crop of weak feeding or foraging power, following one which has made a heavy draft on the soil's available supply of a certain element, may require a more liberal supply of that element in the manure or fertilizer than would have been necessary had it followed a less "exhaustive" crop.

COMMERCIAL FERTILIZERS.

Fertilizers are materials that furnish in more or less available forms one or more of the three so-called essential elements of fertility—nitrogen, phosphoric acid and potash. A fertilizer that supplies all three is known as a "complete" fertilizer. They may be chemical compounds, as nitrate of soda, sulphate of ammonia, etc., or they may be of organic origin, such as bone meal, guano, dried blood, tankage, fish scrap, etc. Frequently the compounded fertilizer as manufactured and sold under brand or trade names is made up of or is a mixture of both classes of materials. Fertilizers should be regarded, by the market gardener especially, as supplements to rather than as substitutes for stable manure. At the same time, they can probably be more profitably used in market-gardening than in any other branch of agriculture, for when associated with thorough and intense cultivation their employment is usually attended by the most beneficial results.

We have noted that a ton of average, well conserved stable manure contains about 10 pounds nitrogen, 5 pounds phosphoric acid, and 10 pounds of potash, so that manure may be considered a complete fertilizer. Experience has shown, however, that for the majority of crops a fertilizer containing at least twice as much phosphoric acid as nitrogen is desirable and we may, therefore, conclude that manure is not well balanced fertilizer for certain crops. It is here that commercial fertilizers find a profitable use in supplying deficiencies, as balancers and in permitting a more economical use of the manure.

Numerous experiments in Canada, as well as in Europe, have proved that in the production of large yields of first-rate quality, especially of market garden crops, the combination of a medium or moderate application of manure with a suitable fertilizer has produced results superior to those obtained from manure alone.

Ready Mixed Fertilizers.

The Dominion Fertilizer Act. This Act requires the registration of every fertilizer offered for sale as such in Canada. [illegible] registration number is given and this number serves as a means of identification, for the Act provides that the guarantee of analysis, together with the registration number of the fertilizer, must be stencilled on each sack or printed on a tag attached thereto.

A bulletin entitled "Fertilizers," giving the "guaranteed" and "actual" analysis of all fertilizers offered for sale in Canada, is published annually by the Department of Inland Revenue, at Ottawa, and we would recommend its perusal by all market gardeners who may contemplate the purchase of ready mixed fertilizers.

Brand Names of Fertilizers.—There are numerous brands of mixed fertilizers on the market, containing varying percentages and proportions of nitrogen, phosphoric acid and potash. Many of these are designated by the manufacturer as especially adapted to certain crops, but the market gardener will find the purchase of the separate fertilizer ingredients the more economical and convenient practice. Many fertilizer mixtures possessing attractive and often very pretentious names are to be found on the market, but a name, especially if a misnomer, is a poor basis whereon to build the reputation of a fertilizer.

To show the futility of relying on a brand name as an indication of the fertilizer's adaptation or value, we take two examples, both from the same page of a recent issue of the bulletin "Fertilizers." Here we find two mixtures, each designated in its name as a special potato fertilizer, having the following analyses:—

Fertilizer No. 1.—Nitrogen 3·32 per cent, available phosphoric acid 6·45 per cent, potash 10·16 per cent.

Fertilizer No. 2.—Nitrogen 1·40 per cent, available phosphoric acid 8·02 per cent, potash 2·53 per cent.

A glance is sufficient to enable one to appreciate the striking contrast between the composition of the two brands. No. 1 is a fairly high-grade fertilizer, while No. 2 might contain about one-third its weight of useless "filler," as its plant food content, per ton, could be supplied by 145 pounds of nitrate of soda, 1,145 pounds of acid phosphate (containing 14 per cent available phosphoric acid) and 100 pounds of muriate of potash.

These two examples may also serve to illustrate the absurdity of offering brands as specially adapted to the needs of special crops. Observe that the proportion of the fertilizer elements in No. 1 is approximately 3:6:10, while in No. 2 it is 1:8:2·5.

Nitrogenous Fertilizers.

Nitrate of Soda (containing 15 to 16 per cent of nitrogen) is the most popular and quickest acting nitrogenous fertilizer. Its nitrogen is directly and immediately available to the growing crops. Owing to the extreme solubility of this compound, and the fact that, on light soils especially, it is liable to get quickly leached to the subsoil by heavy rains, applications of nitrate of soda should not exceed 100 pounds per acre at one time. The best results are secured by small and frequent applications given as top dressings during the earlier weeks of growth, according to the crop's demands for nitrogen.

The function of nitrogen in promoting growth of the vegetative parts renders caution necessary in the application of readily available nitrogenous fertilizers to fruit or seed producing plants during the latter stages of growth, as an excess may prove detrimental by causing abnormal and protracted growth and imperfect or late fruiting and ripening.

Sulphate of Ammonia (containing about 20 per cent of nitrogen) is rather slower in its action than nitrate of soda, and perhaps more suitable for application in moist climates, provided that the soil is adequately supplied with lime which is necessary for the nitrification of its ammonia.

The continued and exclusive use of sulphate of ammonia as a source of nitrogen tends to render the soil distinctly acid. It is most suitable for soils which are plentifully supplied with lime. Experiments in Canada have shown that a mixture of sulphate of ammonia and nitrate of soda may frequently produce results superior to those obtained from the use of either of these materials alone.

Dried Blood—an abattoir by product—is prepared in two grades: Red dried blood (containing 12 to 16 per cent of nitrogen), and black dried blood (containing 6 to 12 per cent of nitrogen and 3 to 4 per cent of phosphoric acid).

The former is a rather scarce commodity and its cost prohibits its extensive employment as a fertilizer. It is prepared by drying the blood with hot water at low temperatures.

Black dried blood is dried at a higher temperature. It is a more or less impure product and is more variable in composition than the red. It is largely employed as a source of nitrogen in high grade ready mixed fertilizers.

Of all sources of organic nitrogen dried blood is undoubtedly the most valuable. It is best adapted to soils which are warm, moist and well aerated and under these favourable conditions the rate of the liberation of its nitrogen will be almost equal to that in sulphate of ammonia. Its rapid nitrification in the soil places it, in the availability of its nitrogen, very close to nitrate of soda.

Tankage—also an abattoir by-product—is produced in several grades which vary widely in their composition according to the proportions of meat, bone, etc., employed in their preparation.

The two principal grades are: concentrated tankage (containing 10 to 12 per cent of nitrogen and 2 to 3 per cent of phosphoric acid) and crushed tankage (containing 5 to 10 per cent of nitrogen and 3 to 12 per cent of phosphoric acid).

In the manufacture of concentrated tankage the animal refuse is submitted to a cooking process and the fat, as far as practicable, removed. The tankage is then evaporated to dryness. Most of the up-to-date abattoirs now subject the material to further treatment with naptha or gasolene as a solvent, with the object of reducing the percentage of fat to a minimum.

Crushed tankage is less valuable and more variable in composition than the concentrated grade. In both the nitrogen is of much slower availability than that in dried blood. They are therefore not so valuable for forcing, being more adapted to crops having a long season of growth.

Tankage, in various forms, enters largely into the composition of ready mixed fertilizers.

There are numerous other abattoir by-products, such as hoof and horn meal, wool and hair waste. In these, however, the nitrogen is so slowly available that they cannot be considered worthy of a place in market garden practice.

It is particularly desirable, in purchasing tankage, to carefully examine the statement of analysis, as this material varies widely in its nitrogen and phosphoric acid content.

Cyanamide and Nitrate of Lime. These compounds are obtained by the fixation of atmospheric nitrogen through electrical energy.

Of late years considerable progress has been made in the preparation of nitrogenous fertilizers the nitrogen of which is derived from the atmosphere. In these processes electrical energy generated by water-power is employed and, at very high temperatures, oxides of nitrogen are induced to combine with lime (as in nitrate of lime) or with lime and carbon (as in cyanamide).

Cyanamide (containing 18 to 22 per cent of nitrogen) when applied to the soil, gradually undergoes conversion therein to ammonia which is subsequently converted into a nitrate of lime and, in this form, taken up by plants. In this final conversion into nitrate cyanamide is similar to sulphate of ammonia.

It has been observed that cyanamide may injuriously affect germinating seed and, for this reason, should be applied, at least a week, prior to seeding time. It is in the form of a very fine powder and is rather disagreeable to apply. If mixed with *dry* superphosphate the objectionable features in its application may be largely avoided. It will be necessary in order to obviate loss of nitrogen that the mixture should be immediately applied.

Owing to the tendency of cyanamide to rapidly absorb moisture when exposed to the atmosphere, it should be carefully stored in a dry place.

Nitrate of Lime (containing 12 to 13 per cent of nitrogen) is a very desirable form in which to furnish immediately available nitrogen. In this respect it is quite the equal of nitrate of soda and both may be similarly employed.

Nitrate of lime is more crystalline in structure and less finely divided than cyanamide. It is, however, even more deliquescent than the latter and, in storage, should be kept in air-tight packages.

Phosphatic Fertilizers.

Bones represent the oldest phosphatic fertilizer and are still largely employed in various forms.

Bone Meal (containing 20 to 25 per cent of phosphoric acid and 3 to 4 per cent of nitrogen) results from the grinding of the raw bone.

The phosphoric acid in bone meal although not immediately available is, by reason of the decomposition of the bone in the soil, gradually liberated in form utilized by crops.

Bone meal is frequently styled a "lasting" manure from the fact that its decomposition is necessarily slow. It gives its best results on soils which are warm, moist and rather light and well aerated. It owes its popularity in green house work, undoubtedly, to the presence of these ideal conditions of soil, moisture and temperature. It further seems probable that here the chief beneficial influence is frequently due to the nitrogen of the bone meal, which is gradually rendered available to the plants at a rate favourable to their rational development.

Steamed Bone Flour (containing 28 to 30 per cent phosphoric acid and about 1½ per cent of nitrogen) results from the steaming or boiling of bone, under pressure, for the removal of the fat and the cartilage.

The loss of nitrogen in this process is to a very large degree compensated for by the higher percentage of phosphoric acid, the absence of fat which retards decomposition in the soil and the greater degree of fineness to which the material may be ground.

Dissolved Bones (Bone Superphosphate). This material contains from 12 to 16 per cent of available phosphoric acid and from 1 to 2 per cent of nitrogen.

Sir John Bennet Lawes, founder of the world-famed experiment station at Rothamsted, England, instituted in the year 1834 experiments with bones as a fertilizer and found that by their treatment with sulphuric acid part of the phosphoric acid in the bone was rendered soluble in water and therefore more readily available to plants. The name given to this product was "superphosphate." Later on, the discovery of the mineral (rock) phosphates furnished a new material which treated in the same way, produced similar results, save, of course, that the product contained no nitrogen.

Dissolved Bone or Bone Superphosphate is now rarely found on the market, but the term "bone superphosphate" is often erroneously applied to ordinary superphosphate.

Rock Phosphate: Apatite, Floats.—There occurs in certain parts of Canada a native phosphate of lime, known as Apatite. This material can be advantageously used in the production of superphosphate (acid phosphate), but does not in the crude state—even when finely ground—furnish available phosphoric acid to growing crops, in appreciable amounts. For this reason it is not used directly as a fertilizer.

Floats is the name of the untreated, but very finely powdered phosphatic deposits found in several of the Southern States (Florida, Tennessee, South Carolina, etc.)

Although not directly soluble in water, it would appear that on soils rich in organic matter and also when applied closely associated with heavy applications of manure, the phosphoric acid of Floats is very slowly liberated in available forms. Nevertheless, it is not a phosphatic fertilizer generally useful in market gardening.

Superphosphate or Acid Phosphate. This is usually sold in two grades containing 14 and 16 per cent, respectively, of available phosphoric acid, but lower grades are not infrequently met with.

Superphosphate is the resultant product when raw phosphate rock is treated with sulphuric acid. By this process part of the phosphoric acid of the rock phosphate is rendered soluble in water and, therefore, immediately available to plants. All the phosphoric acid, however, is not rendered water-soluble by this means. Part is present as "citric-soluble" phosphoric acid, while a small variable proportion remains in the insoluble state. The water-soluble and citric-soluble together constitute the "available" phosphoric acid.

Superphosphate is undoubtedly the most popular phosphatic fertilizer on the market today. The ready availability of its phosphoric acid enables it to exert its maximum beneficial influence during the first season. It is suitable for application to a large variety of soils, but more particularly valuable as a source of phosphoric acids for soils well supplied with lime.

Basic Slag or Thomas' Phosphate Powder (containing from 12 to 18 per cent available phosphoric acid) is a by-product in the manufacture of steel by the Bessemer process.

The crude iron (pig iron) contains a small amount of phosphorus, which would injure the quality of the resultant steel. This is removed by lining the "converters" with lime which absorbs the phosphoric acid, forming a basic phosphate. On removal from the converters this basic slag becomes a hard cinder which is ultimately reduced to a very fine powder by crushers and grinding mills. Since the availability of the phosphoric acid depends largely on the degree of fineness to which the material is reduced, 85 per cent of the sample should be capable of passing through a sieve having 100 wires to the linear inch. This, as well as the percentage of available phosphoric acid, should be stated in the guarantee.

The phosphoric acid of basic slag, though not water-soluble, is largely present in the citric-soluble form and hence may be considered as available.

Basic slag contains varying small proportions of free lime which, together with the lime in combination, frequently represents the equivalent of 40 per cent of lime. The basic or alkaline character of the slag doubtless accounts in a large measure for the marked beneficial effects produced by this fertilizer on sour soils, for which it is in consequence preferred to acid phosphate. Further, basic slag possesses a distinct value for ameliorating the texture of heavy clay loams, rendering them mellower and less plastic. Being slower than acid phosphate in yielding up its phosphoric acid, basic slag should be applied in the autumn or very early in spring, in order to obtain its maximum influence in the first season.

Potassic Fertilizers.

Previous to the war, the principal sources of potash were muriate of potash and sulphate of potash (each containing about 50 per cent of potash) and Kainit (containing about 12½ per cent of potash) obtained from Germany. At the time of writing (1917) these compounds are practically unprocurable, or only at such prices as preclude their profitable use in agriculture. While this condition obtains we must turn our attention to other and domestic sources, but the number of these is small and their supply limited.

Wood Ashes.—The ashes of wood have long been recognized as a fertilizer of very considerable value; indeed their use in agriculture is historic. In all countries, including Canada, practising agriculture they have been highly prized, especially for clover, grapes and fruit trees and leafy crops generally, on sandy and light loams, and it was only with the advent of the German potash salts that their use fell off, though, of course, their production in decreasing quantities of later years, owing to the disappearance of our forests, has been an important factor in making it more and more difficult for the farmer in the older settled districts to obtain them. Their potash is present essentially in the form of a carbonate, probably the most acceptable form for use as a fertilizer. In good unleached, dry wood ashes there may be present from 4 to 6 per cent of potash about 2 per cent of phosphoric acid and from 25 to 35 per cent of lime.

Seaweed represents another and important source of potash. While essentially a potassic fertilizer, it contains also notable amounts of nitrogen and other elements of plant food, so that it might be termed a complete manure. Many varieties in the fresh condition have a composition very similar to that of good barnyard manure.

The manurial value of seaweed is greatly enhanced by its ready decomposition in the soil; it quickly decays, liberating its constituents in forms available for plant nutrition. It is quite unnecessary to compost it, though little loss would ensue if composted with muck or other vegetable matter which would absorb and hold the decomposition products, provided the heap is not exposed to heavy leaching rains.

Seaweed can be employed for all classes of crops, though it will be found most useful for potatoes, roots, vegetables and those with an abundance of foliage, since it is essentially a nitrogenous and potassic manure.

Liberators of Potash in the Soil.

Until such time as the importation of the German potash salts may be resumed or until some other sufficiently large economic source of potash may be discovered, recourse is necessary to other and temporary measures in order to overcome the deficiency of potash in the soil.

No other plant food element can replace potash in its important functions, but it has been observed that where a marked deficiency of potash occurs in a soil, plants growing thereon will assimilate abnormal quantities of soda.

Nitrate of Soda.—It would seem, therefore, that nitrate of soda besides furnishing nitrogen might offer a partial solution of the problem. However, while this fertilizer may directly furnish to some extent soda as a substitute, its value as an indirect source of potash is, undoubtedly, due chiefly to its influence upon the more or less insoluble stores of potash in the soil, from which it may liberate appreciable amounts for crop use.

Sodium Chloride (common salt).—For the same reason common salt has frequently been used to increase the yields of mangels, potatoes and grain crops.

Lime and Lime Compounds.—The function of lime compounds as potash liberators has already been referred to, but this feature is of secondary importance compared with their other useful properties.

Gypsum, commonly known in the ground form as land plaster, is a naturally occurring sulphate of lime. Although supplying lime it is of no value for the correction of acidity (sourness) of soils, for which purpose lime or ground limestone must be employed. But the furnishing of lime does not constitute its chief manurial value. It has the property of acting on the insoluble potassic compounds of the soil, setting free for plant use a part of their potash. This is its most important function and it is this property that has made it specially beneficial as a top dressing for clover, a crop that particularly responds to potash. The application of land plaster is usually from 300 to 600 pounds per acre, which may be broadcasted on the prepared land and harrowed in.

The market gardener is, after all, probably less affected by the potash shortage than are his brother agriculturists, for experiments have indicated that where large, or even medium, applications of good manure are made, the addition of further potash as a fertilizer is frequently unnecessary.

Choice of Fertilizers for the Market Garden.

It is evident that the primary object in the application of fertilizers is to supplement the soil's supply of immediately available plant food and thus ensure adequate and proper nourishment of the crop during the most critical stages of growth. It, therefore, follows that the choice of materials should generally fall on those which will most readily yield up their elements, i.e., those which are more or less soluble. A judicious selection of the several elements and their most desirable forms is as a rule possible only by the employment of the separate fertilizer materials.

In many of the ready-mixed "complete" fertilizers the plant food ingredients are present in part in slow-acting forms which, although suitable, perhaps, for certain crops with a long period of growth, are not, as a rule, desirable in market gardening in which it is necessary to exert a marked and favourable influence upon growth and incidentally to control the rate and amount of plant food assimilation at different seasons. Such is more nearly attainable through the judicious use of quick-acting fertilizers.

When we bear in mind the numerous factors which it would be necessary to take into consideration in determining the composition and quantity of a fertilizer designed to meet the specific requirements of a certain crop, the futility of attempting, with any degree of precision, to prescribe "standard mixtures" will be recognized. Within certain limits, of course, we may be able to advise the use of special fertilizers for crops, the peculiar appetities of which are known, e.g., the predilection of cabbage for nitrogen, of turnips for phosphoric acid and of potatoes for potash, but no specific formulæ for the different crops, which might prove misleading, will be given. It remains for the market gardener to discover by experiment on his own soil its more exact fertilizer requirements.

It may be pointed out, however, that in market gardening there is not the same necessity for close figuring as there is in general farming with its wider areas and less valuable crops, so that it will be well to err on the side of excess rather than on that of frugality in the application of fertilizer materials, bearing in mind that any surplus of phosphoric acid and potash over immediate requirements will be retained in the soil for future crops.

Composition of the Principal Fertilizer Materials.

Fertilizing Material.	Nitrogen.	Phosphoric Acid. Available.	Phosphoric Acid. Total.	Potash.
	p. c.	p. c.	p. c.	p. c.
Nitrogenous Fertilizers				
Nitrate of soda	15-16			
Sulphate of ammonia	19-20½			
Cyanamide	18-22			
Nitrate of lime	12-13			
Dried blood (red)	12-16			
Nitro Phosphatic Fertilizers				
Dried blood (black)	6-12		3-4	
*Concentrated tankage	10-12		2-3	
**Crushed tankage	5-10		3-12	
Dried fish scrap	7-9		6-8	
Bone meal	3-4		20-25	
Steamed bone flour	1-2		26-30	
Dissolved bone	1-2	13-16	15-17	
Phosphatic Fertilizers				
Ground phosphate rock			25-35	
Superphosphate (acid phosphate)		12-16	14-20	
Basic slag		10-18	12-23	
Potassic Fertilizers				
Muriate of potash				48-52
Sulphate of potash				47-51
Kainit				12-13
Nitro-Phospho-Potassic Fertilizers				
Tobacco stems	2-3		3-5	5-8
Phospho-Potassic Fertilizers				
Wood ashes (unleached)			1½-2½	4-6

*Consisting chiefly of flesh offal.
**Contains varying proportions of bone.

Standard Fertilizer Mixtures.

If asked to recommend a "standard" fertilizer generally useful for market garden crops, we would suggest one containing 4 per cent nitrogen, 8 per cent available phosphoric acid and 8 per cent potash as approximating the average requirements. Such a fertilizer might be compounded from nitrate of soda, superphosphate (acid phosphate) and muriate of potash as follows:—

Mixture "A."

Fertilizer Materials.	Nitrogen.	Phosphoric Acid.	Potash.
	lb.	lb.	lb.
530 lbs. nitrate of soda (15% nitrogen)	80		
1,000 " superphosphate (16% available phosphoric acid)		160	
320 " muriate of potash (50% potash)			160
1,850 lbs. in total mixture	80	160	160

The amount of 1,850 pounds, thus obtained, would represent the equivalent in plant food constituents of one ton of 4 : 8 : 8 goods.

According to the nature of the soil and crop, the mixture might be applied at the rate of from 500 to 1,000 pounds per acre, though occasionally, under special conditions, larger applications may be profitably employed. As it is frequently desirable to use more than one source or form of element in the mixture, in order to effect a more gradual, continuous nutrition of the crop, part of the nitrogen and phosphoric acid may be furnished in less available forms. Thus, we might prepare the following mixture, which similarly would be the equivalent of one ton of a 4 : 8 : 8 fertilizer.

Mixture "B."

Fertilizer Materials.	Nitrogen.	Phosphoric Acid.	Potash.
	lb.	lb.	lb.
200 lbs. nitrate of soda (15% nitrogen)	30	....	....
300 " dried blood (12% nitrogen)	36	....	....
400 " bone meal (3·5% nitrogen, 20% phosphoric acid)	14	80	....
500 " acid phosphate (16% available phosphoric acid)	....	80	....
320 " muriate of potash (50% potash)	....	....	160
1,720 lbs. in total mixture	80	160	160

If—as at present—potash is unobtainable, the following mixture, containing only nitrogen and phosphoric acid, may be prepared:—

Mixture "C" (without Potash).

Fertilizer Materials.	Nitrogen.	Phosphoric Acid.	Potash.
	lb.	lb.	lb.
250 lbs. nitrate of soda	37.5	....	
375 " dried blood	45	....	
500 " bone meal	17.5	100	
625 " acid phosphate	....	100	
1,750 lbs. in total mixture	100	200	

This mixture (without potash) contains the other component materials, and in consequence also the nitrogen and phosphoric acid, in exactly the same proportions as are present in the preceding one. The quantity of 1,750 pounds, thus obtained, is equal in its total nitrogen and available phosphoric acid contents to one ton of a 5:10:0 fertilizer.

The foregoing mixtures may be considered as suitable for a basic or initial application, to be supplemented, as conditions dictate, by subsequent top dressings of special fertilizers, such as nitrate of soda.

The following table shows the corresponding quantity *per acre and per square rod* of each component of the mixtures A, B and C, when these are applied at the respective rates of *500 and 1,000 pounds, per acre.*

Mixture "A."

	Per Acre.		Per Square Rod	
	500 lbs. dressing.	1,000 lbs. dressing.	500 lbs. dressing.	1,000 lbs. dressing.
	lb.	lb.	lb. oz.	lb. oz.
Nitrate of soda. ...	143½	287	0 14⅓	1– 13
Acid phosphate. ...	270	540	1 11	3 6
Muriate of potash ...	86½	173	0– 8½	1 1
Total mixture.	500	1,000	3 2	6 4

Mixture "B."

Nitrate of soda	58	116	0– 6	0 12
Dried blood.	87	174	0 8⅓	1 1
Bone meal.	116½	233	0 11⅔	1 7
Acid phosphate.	145½	291	0–14½	1 13
Muriate of potash	93	186	0– 9⅓	1– 3
Total mixture.	500	1,000	3– 2	6 4

Mixture "C" (without Potash).

Nitrate of soda	71	142	7 0	0 14
Dried blood	107	214	0 10	1 5
Bone meal	143	286	0 14½	1 13
Acid phosphate	179	358	1 2⅓	2 4
Total mixture	500	1,000	3 2	6 4

To preserve accuracy in the figures given in the foregoing table, it has been necessary to include fractions of pounds and ounces. In general practice, however, such a degree of accuracy need not be observed.

According to the cost and procurability of the various fertilizer materials, other sources of the several plant food substances may be employed to either wholly or partially replace one or more of those given in examples A, B and C. For instance, sulphate of ammonia, as a source of nitrogen, may be substituted for either nitrate of soda, dried blood or both. Since sulphate of ammonia contains 20 per cent of nitrogen, as compared with 15 per cent in nitrate of soda and 12 per cent in dried blood, 75 pounds of this material is equal to 100 pounds of nitrate of soda or 125 pounds of dried blood.

Home-mixing of Fertilizers.

The same raw materials used by the manufacturers are available to the market gardener in compounding his mixtures. The inert "filler" or "make-weight," frequently added by the manufacturer, serves only to reduce the percentages of plant food, thus enabling the product to be marketed at a lower price per ton, though, in some cases, it may be used to keep the mixture in a friable condition, where a long period is likely to elapse between its manufacture and application.

The practice of ‸ ‸e-mixing generally results in a saving of from 25 to 35 per cent in cost of th‸ ‸ials and possesses the additional advantage of enabling the market gardener to prepare his mixtures in such quantities and proportions as the occasion demands. Moreover, in the employment of the separate materials he knows the source and availability of each plant-food constituent.

The operation of home-mixing may be simply and efficiently performed on the barn floor or other firm level floor by means of a shovel, a screen and a mallet or wooden post to break the lumps.

Having assembled the sacks of materials from which the batch is to be prepared, empty the contents of each sack separately on the mixing floor. If the material has set in a hard firm mass use the tamper or mallet to reduce the lumps before passing it through the screen which should have about 10 wires to the linear inch.

The lumps which are too coarse to put through the screen may be separately crushed and, when reduced to a sufficient degree of fineness, added to the heap.

Each component of the batch having undergone this preparation, its incorporation with the others may proceed.

The component—usually the phosphatic fertilizer—entering most largely into the mixture ought to be first spread on the floor, the others being superimposed in successive layers. The batch is then turned by shovelling first to one side, then to the other for, say, four or five times. After turning once, the whole batch should be passed through the screen to insure the absence of lumps and to facilitate mixing.

One ton is usually a sufficient quantity to mix in one batch.

It is, as a rule, desirable to apply the fertilizers to the land at once, or within 24 hours after mixing, in order that hardening or cementing of the materials may be avoided.

Never mix basic slag, wood ashes or other substances containing free caustic lime with sulphate of ammonia, unless for immediate application, as the lime, by displacing the ammonia, causes its escape as gas and a loss in valuable plant food ensues.

Methods Employed in the Application of Fertilizers.

Where the areas to be fertilized are extensive the application may be performed by means of a broadcast sowing machine or drill. In market gardening, however, fertilizers are generally applied by hand from a pail or from a sack slung over the shoulder.

A more expeditious method than the latter for the application of fertilizers to larger areas may be found in the use of a two-handed sowing "hopper" or basket. This might be described as a crescent-shaped, canvas covered frame with waist and shoulder straps attached. Both hands are used in sowing, and to obtain the proper rhythmical motion, it is necessary that the right hand be swung backwards from the hopper as the right foot advances, and vice versa.

The size of the handful and the length of the stride may be regulated according to the desired rate of application.

Greater uniformity in application may often be the better assured by a second broadcasting of the fertilizer, traversing the area at right angles to the direction of the first application.

Where the quantity of fertilizers to be applied is small—as, for instance, in top-dressings of nitrate of soda—in order to ensure uniformity of application, it is desirable to increase the bulk of the fertilizer by mixing it with a quantity of loose dry soil.

Time of Application.

As already stated, the opportune time at which fertilizer applications should be made will be decided to some extent by the nature of the crop, of the climate, and of the fertilizer materials employed.

Speaking generally, most of the phosphatic and potassic fertilizers should be applied during the final cultivation of the land preparatory to seeding. Part of the nitrogenous fertilizer may be applied at the same time, the remainder (assuming it to be in the form of nitrate of soda) being given as a top dressing in two or more subsequent applications, according as circumstances dictate.

Immediately after their application to the thoroughly prepared land, the fertilizers should be incorporated with the surface soil by means of harrows or light cultivater.

It seems desirable here to again emphasize the fact that fertilizers cannot fully play their part in crop nutrition unless the soil is in good tilth. It must be mellow, warm, moist and well aerated, and these favourable conditions will be promoted by furnishing humus-forming material (as in barnyard manure), drainage, if necessary, and a thorough, frequent working of the surface soil.

SUGGESTIONS TO MEET THE FERTILIZER REQUIREMENTS OF SPECIAL CROPS.

Cabbage.

This crop is a gross feeder and particularly responds to heavy applications of manure and nitrogenous fertilizers. It requires also liberal supplies of phosphoric acid and, if the soil is light, potash, but, when heavily manured, may not require additional potash in the fertilizer. For cabbage, even on well-manured land, the maximum quantity of one or other of the basic mixtures may be advantageously applied and subsequently supplemented, if growth is not satisfactory, by top dressings of nitrate of soda, say, at the rate of 100 pounds per acre in each application.

Brussels Sprouts, Cauliflower, Lettuce, Spinach.

The fertilizing of these crops should be almost as liberal as that recommended for cabbage. They may, however, be injured by an excess of nitrogen which, in a fertilizer for these crops, should not, as a rule, exceed the equivalent of 250 pounds of nitrate of soda per acre. In the case of brussels sprouts, cauliflower and, in some degree, cabbage, a part of the nitrogenous fertilizer may be advantageously withheld until after the heads have begun to form.

Potatoes.

In addition to a moderate dressing of the best barnyard manure available, preferably applied and worked into the soil the previous autumn, a medium application—say, 600 to 800 pounds per acre—of the basic mixture may be employed for potatoes. Potash, being the dominant ingredient required in a fertilizer for this crop, should, if procurable, be applied on soils of the lighter types at the rate of 200 pounds of muriate or sulphate of potash per acre. Spring application of manure for this crop is undesirable, since the direct contact of the manure with the tubers is apt to encourage the development of scab.

While in general farm practice, particularly in moist climates, the plan usually adopted is to broadcast the fertilizers on the prepared land and harrow them in, a more direct—and perhaps more economical—way that may be found desirable in connection with this crop is to put the fertilizers in the furrow or drill opened for the sets. Though some first spread the fertilizer in the furrow, covering with a little soil and then planting the sets, it is considered by others that better results are obtained by first planting the sets, covering lightly with soil, then adding the fertilizers, and finally filling with soil. In either case the fertilizer should not come into direct contact with the sets.

Early varieties of potatoes may derive benefit from additional nitrogen, which may be supplied in top dressings of nitrate of soda applied during the early stages of growth.

Wood ashes may serve as a valuable source of potash for the potato crop, but, since their strong alkalinity tends to encourage the development of potato scab, they should not, as a rule, be used directly for this crop. However, no harmful results need be anticipated from a moderate dressing of wood ashes, if they be applied and worked into the surface soil at least two weeks before planting time.

Turnips, Radishes.

If furnished with a fairly liberal supply of barnyard manure, these crops frequently require only phosphoric acid, which may take the form of from 500 to 700 pounds of superphosphate or, if the soil is especially heavy or in need of lime, from 600 to 800 pounds of basic slag per acre. It has been found that basic slag has been instrumental in checking the development of "club root," prevalent in acid soils. If the land has been only lightly manured, a top-dressing of 100 to 125 pounds of nitrate of soda, per acre, applied before thinning the plants, may prove useful in imparting early vigour to the crop.

Beets, Carrots and Parsnips.

It has been repeatedly shown that these crops do better when following a manured crop than when receiving direct applications of manure. They have greater difficulty than either cabbage or turnips in securing their potash supply. Accordingly, for these crops 100 to 150 pounds of muriate or sulphate of potash is suggested. If wood ashes are available, they might be used here, at the rate of about 30 to 50 bushels per acre. Either of the foregoing together with a medium application of the basic fertilizer mixture may be advantageously applied.

Beans and Peas.

These, in common with all members of the legume family, are particularly benefitted by applications of potash and lime, therefore, wood ashes (which supply both these elements) would be very suitable for their direct fertilization. Muriate or sulphate of potash, if procurable, may be used at the rate of 100 to 150 pounds per acre on light soils.

Although not specially requiring nitrogen in the fertilizer, a small amount of nitrate of soda usually encourages the growth of these crops in the early stages. Basic slag, applied at the rate of about 500 to 750 pounds per acre, would prove a satisfactory phosphatic fertilizer on most types of soils.

Since the function of nitrogen is particularly leaf development, a too liberal application of an available nitrogenous fertilizer will, in moist warm weather, induce a growth of the vine at the expense of the pods and seeds.

Onions.

Like beets, carrots and parsnips, onions seem to produce the best results on a loamy, rich soil which has been well manured for the preceding crop. They are gross feeders and respond to heavy fertilizing. Large quantities of nitrogenous fertilizers are, however, not desirable, since such cause "thick necks" and abnormal development of "top."

The maximum application of one or other of the basic mixtures would, as a rule, be required for this crop, with subsequent top dressings of nitrate of soda, applied sparingly and as frequently as the appearance of the crop dictates.

Top dressing with nitrate of soda is a common practice with onion growers; the maximum quantity that can be applied with safety in any one dressing will be 200 pounds per acre.

Celery.

Celery resembles onions in its fertilizer requirements and is benefitted by liberal manuring. Muck soils which supply an abundance of water for the crop have been found especially suited to the growth of celery, more particularly when a potassic fertilizer is employed.

Sweet Corn.

This crop prefers well manured, loamy soils and should receive a medium application of the basic fertilizer mixture to force an early growth. Nitrogenous fertilizers should not be too liberally applied, as excess of nitrogen would have a tendency to delay the formation and ripening of the ears.

Tomatoes.

Tomatoes ought not to be heavily manured, as an excess of nitrogen encourages an abnormal development of vine at the expense of the fruit production. It is a crop, however, that benefits from unusually large applications of a phosphatic fertilizer. It is desirable to withhold a part of the nitrogenous fertilizers until the fruit has set, when dressings of nitrate of soda may be given to stimulate growth and increase yield. This procedure is applicable in the case of most other crops which are grown for their fruit.

Asparagus.

In the preparation of the asparagus bed large quantities of manure should be used. The crop requires abundant supplies of available plant food, not only to produce a vigorous growth of early shoots but also of the roots and tops after cutting has ceased, which ensures a large production the following season. Nitrate of soda should be given sparingly on the appearance of the first shoots. If the soil is not rich, the manure may be supplemented by an application of 1,000 pounds per acre of the basic fertilizer recommended.

Rhubarb.

This crop requires treatment similar to that prescribed for asparagus and responds to heavy applications of manure.

Cucumbers, Muskmelons, Water Melons, Pumpkins and Squash.

For these crops the use of a rich manure compost in the hill seems to produce most satisfactory results. They require liberal supplies of available plant food, but, having a long season of growth, nitrogen may be given mostly in slow acting forms such as bone meal, dried blood, tankage, etc. Top dressings of nitrate of soda may be applied subsequently as required.

Small Fruits: Strawberries, Raspberries, Currants, Thimbleberries, etc.

These may be fertilized similarly to the potato crop, only nitrogenous fertilizers should be applied more cautiously and less manure will suffice.

With respect to strawberries, it is important that the land, previous to setting out the plants, should be abundantly enriched with nitrogenous organic matter, as by a liberal application of manure. This may frequently be supplemented with profit by a dressing of, say, 500 to 800 pounds of the basic fertilizer, well worked into the soil. To ensure a sufficiency of nitrogen it is desirable, on poor soils, to apply nitrate of soda (100 pounds per acre) as a top dressing after the plants have blossomed.

In market gardening the choice of fertilizing materials will depend not only on their suitability, but also on their relative cost and procurability. As a general rule, the slow-acting materials should be applied earlier than those containing their plant food in more available forms, except where it is desirable to furnish a mixture of quick and slow-acting sources of nitrogen or phosphoric acid, or both, in order to effect the more gradual nourishment of a crop having a long season of growth.

The intensity of the fertilizing will, in each case, be determined by the character of the soil and the quantity and quality of the manure used. Speaking generally, the heavier the manuring the less nitrogen and potash will be needed in the fertilizer.

Influence of Fertilizing Materials on the Texture, etc., of the Soil.

Certain forms of fertilizers may exert upon the soil influences apart from those due to their fertilizing properties. These may be harmful or beneficial.

Nitrate of Soda has a beneficial action in liberating potash from insoluble potash compounds, an effect which is often very noticeable on clay soils. If applied liberally, however, year after year, it will tend to destroy the granular structure of heavy soils causing them to remain wet and puddle readily; the soil will be "sticky" after rain, eventually drying into large, hard lumps. This injurious effect on the tilth of heavy clay soils is caused by the residual soda of the nitrate of soda, which becomes converted into carbonate of soda, a strong alkali, and causes deflocculation of the clay, rendering it sticky, plastic and difficult to work. These conditions would be only intensified by the use of lime compounds and a suggested remedy is the application of acid phosphate and sulphate of ammonia.

Sulphate of Ammonia, as we have already pointed out, uses up the lime of the soil and further applications may prove ineffective in presence of acid conditions which hinder bacterial activity. For such a condition liming is the remedy.

Probably the best plan to adopt would be the alternate or combined use of nitrate of soda and sulphate of ammonia.

Nitrate of Lime.—Of the new nitrogenous fertilizers, already briefly referred to, this compound—a most desirable form of available nitrogen—by leaving lime as a residue, has a beneficial effect on soils deficient in this element.

Cyanamide may produce a poisonous effect on germinating seeds and young plants, but this action is noticeable only for a short period after application. It should be applied and worked into the soil two weeks before seeding.

Acid Phosphate, by virtue of the effect of its contained sulphate of lime (gypsum) in liberating potash from insoluble potash compounds, may prove beneficial on certain soils deficient in available potash. On soils of an acid nature the sulphuric acid, remaining after removal of the lime, occasionally produces detrimental effects by increasing the soil acidity.

Basic Slag, as already stated, contains considerable amounts of lime and lime compounds which, particularly on acid soils, act beneficially. Under certain conditions the alternate or combined use of acid phosphate and basic slag is recommended.

Muriate of Potash and Sulphate of Potash.—The chlorine and sulphuric acid of these salts combine with the lime and magnesia of the soil, forming chlorides and sulphates. The formation of these compounds, plentifully present in drainage waters of the fertilized areas, prevents the soil from becoming sour due to the accumulation of acid. Naturally the intensive and continued use of these potash compounds would tend to deplete the soil of lime, rendering liming necessary.

Carbonate of Potash—the form in which potash is present in wood ashes is a powerful neutralizer of acids and hence exerts a beneficial action on sour soils. But, if used in excess on heavy soils, it will exert an influence similar to that of sodium carbonate in destroying a favourable tilth.

SUMMARY.

Market gardening represents the highest degree of "intensive farming" and demands an intimate knowledge of the factors controlling the quantity and quality of the produce.

Quality ranks in importance with earliness and yield and is the factor which largely determines the commercial as well as the culinary value of the produce. A quick, uninterrupted growth, secured by the provision of suitable and adequate supplies of readily available plant food, is essential to the production of quality.

The Soil must be well drained and adequately supplied with humus, as furnished by farm manures, in order to be a satisfactory medium for the growth of the market garden crops.

Manure represents the chief source of humus and is the main "stand-by" of the market gardener. It may be used in very liberal quantities, as intensive cultivation promotes its rapid decomposition.

Stable manure is exceedingly variable, its composition depending on the kind, age, function and food of the animal producing it, the quality and the nature of the litter employed and the care taken in the storage.

The analysis of a large number of samples of mixed horse and cow manure, from animals well fed and sufficiently bedded with straw to hold all the liquid excreta, showed an average content per ton of 10 pounds nitrogen, 5 pounds phosphoric acid, and 10 pounds potash.

Losses from manure occur through fermentation and leaching. To reduce such losses to a minimum the manure heap must be kept firmly packed, sufficiently moist and protected from the action of heavy rains.

The liquid portion contains more than one-half the nitrogen and at least three-fourths of the soluble potash of the total amounts excreted by the animal. As, at the present time, manure represents the almost exclusive source of potash for the market gardener, the desirability of conserving the liquid portion is obvious.

The value of manure depends not only on its fertilizing properties, but also on its physical and biological influences in the soil.

The Compost Heap finds an appropriate place in market gardening and provides a means of profitably utilizing all kinds of vegetable refuse, which otherwise go to waste.

Nitrification is effected by certain favourable bacteria which, under suitable conditions, convert the nitrogen of organic matter into nitrates for the use of the plant. Nitrification is encouraged by a thorough working of the soil and by conditions favourable to aeration and drainage. It is also beneficially influenced by a slightly alkaline condition of the soil as brought about by liming.

Liming especially on soils containing a large amount of organic matter humus, is beneficial in correcting acidity and in liberating mineral plant food form insoluble soil compounds. It improves the texture of clay soils by destroying their cohesiveness.

Green Manuring or the turning under of green crops is a valuable means of supplementing the manure supply. If legumes are used for this purpose a large amount of valuable nitrogen may thereby be added to the soil.

Commercial Fertilizers should be regarded as supplements to rather than as substitutes for manure. When accompanied by thorough soil cultivation, as practised in market gardening, the use of fertilizers may be attended with very beneficial results.

Nitrogen, phosphoric acid and potash are the three ingredients considered in fertilizing. Each performs its own particular function in plant nutrition and an excess of one cannot make up for a deficiency of another.

Analyses of Plants do not furnish accurate indications of their fertilizer requirements, as one kind of plant may have greater powers than another of assimilating a certain element. Nevertheless, the amount and nature of plant food removed from the soil by the preceding crop may, to some extent, determine the fertilizer application for the succeeding crop.

The brand name of a ready-mixed fertilizer does not necessarily indicate its suitability for specific purposes.

Home-mixing and Choice of Fertilizer Materials.—Home-mixing usually effects a saving of from 25 to 35 per cent in cost of materials and has the additional advantage of permitting the preparation of mixtures from the kind of materials and in the proportions which the occasion demands.

The use of fertilizers containing their plant-food in soluble, readily available forms is generally recommended for market garden crops, the majority of which should be grown quickly for the best results.

Some of the factors influencing the choice of the kind, quantity and proportion of the fertilizer materials to be used are: the nature of the crop, the character of the soil and its drainage, the intensity and manner of cultivation, climatic conditions and the amount of stable manure to be applied in conjunction with the fertilizer.

It has been impossible to give specific fertilizer prescriptions for the various vegetables and fruit owing to the number of factors involved, but suggestions have been offered on broad lines for the larger number of market garden crops.

Reference has repeatedly been made in this bulletin to what we have termed the rational use of fertilizers, namely the employment of these materials in conjunction with or supplemental to the application of farmyard manure. As an illustration or an example of such use we furnish in the appendix a record of experimental work with fertilizers and manure on a number of market garden crops conducted on one of the experimental stations in Eastern Canada in the season of 1915. The data show that with very few exceptions the application of manure and fertilizer has proven more profitable than manure alone. Similar results would not, of course, always and everywhere be obtained; their insertion in this bulletin, however, will furnish the reader with information as to the nature of the yields which may be expected from a judicious use of fertilizers with manure, provided the season is favourable.

APPENDIX.

Fertilizer Experiments with Market Garden Crops Conducted in the Year 1915.

The primary object of these experiments was to ascertain whether it might not prove more profitable, in general practice, and especially in cases where manure was scarce or expensive, to use half the ordinary quantity of manure in conjunction with commercial fertilizers, than to rely on the full quantity of manure alone.

Carrots, Turnips and Parsnips.

TABLE No. 1.—Fertilizer Experiment with Carrots, Turnips, and Parsnips.

Variety.	Plot A. Manure alone 30 tons per acre.		Plot B. Manure 15 tons per acre; nitrate of soda 130 lb., superphosphate 400 lb., muriate of potash 120 lb.		Increase in yield over manure alone.	
	Yield per acre.		Yield per acre.			
Carrots.	bush.	lb.	bush.	lb.	bush.	lb.
Danver's Improved Half Long	580	40	592	18	11	28
Early Scarlet Horn	446	34	459	18	12	34
Half Long Chantenay	559	34	744	24	184	40
Average increase in yields of "Manure and Fertilizer" Plot					69	33
Turnips.						
Bangholm Purple top	1,320	—	1,584	—	264	—
Best of All	1,710	36	1,900	40	190	4
Carter's Invicta	1,119	18	1,161	30	42	12
Favorite	1,192	14	1,108	40	-84	24
Hall's Purple Top	1,077	6	1,108	40	31	34
Skirving's Purple Top	1,244	4	1,393	46	149	42
Sutton's Purple Top	1,372	40	1,478	20	105	30
Westbury Purple Top	1,383	18	1,584	—	200	32
Average increase in yields of "Manure and Fertilizer" Plot					124	48
Parsnips.						
Improved Hollow Crown	554	16	568	24	14	8
Intermediate	462		488	16	26	16
Average increase in yields of "Manure and Fertilizer" Plot					20	12

The value of the barnyard manure was placed at the conservative figure of $1 per ton and the fertilizers valued at the pre-war prices of $3 per hundred pounds of nitrate of soda, 80 cents per hundred pounds of superphosphate, and $2.50 per hundred pounds of muriate of potash. The cost of the manure applied to plot A is $30 per acre, while the combined manure and fertilizers applied to plot B cost $25.10 per acre.

The results from this experiment with carrots, turnips and parsnips most distinctly favour the combined manure and fertilizer application.

In one instance only (a single variety in the turnip area) has plot A produced a greater yield than plot B, a striking exception which proves the general consistency of the results.

Celery and Onions.

TABLE No. 2.—Fertilizer Experiment with Celery and Onions.

Variety.	Plot A. Manure alone 30 tons per acre. Yield per acre.		Plot B. Manure 15 tons per acre; nitrate of soda 240 lbs., superphosphate 400 lbs., muriate of potash 200 lbs. Yield per acre.		Increase in yield over manure alone.	
Celery.	ton.	lb.	ton.	lb.	ton.	lb.
Evans Triumph	20	1,800	24	1,720	3	1,920
French Success	16	[illegible]	28	1,200	12	1,880
Giant Pascal	34	1,520	37	800	2	1,280
Nells M[illegible]	19	1,600	27	1,000	7	1,400
Winter Queen	21	840	29	1,840	8	1,000
Average increase in yields of "Manure and Fertilizer" Plot					7	40
Onion.						
Ailsa Craig	5	1,880	9	1,800	3	1,920
Danver's Yellow Globe (from seed)	25	160	27	1,176	2	1,016
Danver's Yellow Globe (from sets)	25	1,440	27	1,11[illegible]	1	[illegible]
Johnson's Dark Red Beauty	7	1,[illegible]40	17	1,6[illegible]0	9	1,8[illegible]0
Large Red Wethersfield (from seed)	7	1,840	13	400	5	560
Large Red Wethersfield (from sets)	23	200	23	860		660
Red Globe	12	1,040	19	280	6	1,240
Salzer's Giant Red Wethersfield	11	1,760	15	1,680	5	1,920
White Globe	12	1,080	16	1,000	3	1,920
Average increase in yields of "Manure and Fertilizer" Plot					4	557

The fertilizer application used in the celery and onion experiments (Table No. 2) was heavier than that applied to the root crops. In consequence, the cost of the treatment accorded plot B in this instance exceeds that of plot A by $4.0[illegible] per acre. Nevertheless, the increased yield from plot B was sufficiently large to more than repay the extra cost.

Remarkable consistency is again in evidence, the yields from plot B—receiving both manure and fertilizers—exceeding those from plot A with but a single exception.

Tomatoes.

TABLE No. 3.—Fertilizer Experiment with Tomatoes.

Variety.	Plot A. Manure alone, 30 tons per acre. Yield per acre. Ripe.		Green.		Total.		Plot B. Manure, 15 tons per acre, [illegible] nitrate of soda, [illegible] superphosphate, [illegible] muriate of potash, 175 lbs. Yield per acre. Ripe.		Green.		Total.		Increase in yield over manure alone.	
	tons.	lbs.	tons.	lbs.	tons.	lbs.	tons.	lbs.	tons.	lbs.	tons.	lbs.	tons.	lbs.
Bolgiano E. E. Wealthy	17	816	4	1,248	22	64	18	204	3	528	21	737		1,327
Rennie's Earliest	9	1,040	5	1,424	15	464	14	288	3	1,072	17	1,360	2	896
Lane Bro's N. Adirondack	12	1,568	1	984	14	552	14	1,376	3	1,672	18	1,048	3	1,496
Bonny Best	7	1,032	6	512	13	1,544	11	1,936	7	1,232	19	1,168	5	1,624
Johnson's Jack Rose	11	1,120	2	896	14	16	5	1,968	9	1,584	15	1,552	1	1,536
Chalk's Early Jewel	11	1,120	4	1,792	16	912	3	1,072	17	272	20	1,344	4	432
Sunnybrook Earliana	9	1,448	6	512	15	1,960	9	1,856	5	336	15	192		1,768
Alacrity 12B	12	1,004	3	1,616	16	620	11	1,392	5	336	16	1,728		1,108
" 14B	17	1,904	3	1,072	21	976	14	1,376	7	1,776	22	1,152	1	176
Prosperity	10	672	2	1,984	13	656	12	480	1	1,584	14	64		1,408
Matchless	8	1,136	4	1,792	13	928	12	210	3	1,344	15	1,554	2	626
Trophy	7	144	4	160	11	304	10	944	4	704	14	1,648	3	1,344
Livingstone Globe	11	832	5	336	16	1,168	14	1,296	3	1,696	18	992	1	1,176
Ponderosa	14	1,920	4	1,248	19	1,168	17	816	5	336	22	1,152	2	1,984
Ponderosa Golden	12	1,548	3	1,072	16	620	17	272	2	1,984	20	256	3	1,636
Average increase in yields of "Manure and Fertilizer" Plot													2	26

To meet the tomato plant's well known demand for phosphoric acid, a larger quantity of superphosphate (with a smaller amount of nitrate of soda) as compared with the treatment in the other experiments has been applied to plot B.

The combined cost of the fertilizer and manure applied to plot B in the tomato experiment is intermediate between those of the two preceding experiments, being represented by $27.77 per acre, the cost of manure for plot A, as in all the experiments, remaining at $30 per acre.

Of 15 varieties of tomatoes included in the test, but three failed to show an increase in yield from plot B over that from plot A, again furnishing evidence as to the value of manure with fertilizers.

Peas.

TABLE No. 4.—Fertilizer Experiment with Peas.

Variety.	Length of Row.	Plot A. Manure alone 30 tons per acre. Row A. Cost of Fertilizer, per row, 9 cents.		Plot B. Manure 15 tons per acre, superphosphate 320 lbs., muriate of potash 130 lbs. Row B. Cost of Fertilizer, per row, 6½ cents.		Increase in yield over manure alone.	
	ft.	lb.	oz.	lb.	oz.	lb.	oz.
Advancer	33	29	—	30	—	1	—
American Wonder	33	15	10	18	5	2	11
Dainty Duchess	33	13	11	14	12	1	1
Early Giant	33	29	10	31	8	1	14
Gradus	33	23	7	27	—	3	9
Gregory's Surprise	33	22	6	24	2	1	12
Heroine	33	35	—	37	—	2	—
Juno	33	24	—	25	8	1	8
Premium Gem	33	17	10	15	9	−2	1
Quite Content	33	35	1	32	8	−3	7
Stratagem	33	21	—	34	—	3	—
Sutton's Excelsior	33	23	10	26	—	2	6
Thomas Laxton	33	24	—	28	8	4	8
Telephone	33	26	—	34	—	8	—
The Laxton	33	23	—	26	—	3	—
Average increase in yields of "Manure and Fertilizer" Plot						2	11

The fertilizer mixture applied to plot B in this experiment with peas includes phosphoric acid and potash only, the nitrogen having been omitted.

Here the cost of the manurial and fertilizer treatment of plot B amounts to $20.81 per acre, or 6½ cents per row, as compared with $30 per acre, or 9 cents per row, on plot A.

Only two out of a total of fifteen varieties have failed to produce an increased yield on plot B, the area which received both manure and fertilizers.

General Discussion of the Results from the Vegetable Experiments.

The results obtained in these fertilizer tests with vegetables permit of but one conclusion, the profitable use of fertilizers with manure. The evidence proves in an incontrovertible way the economical advantage of a medium application of manure with suitable commercial fertilizers as compared with the use of a large quantity of manure alone.

Possibly further investigations may suggest the desirability of altering the amounts and proportions of the fertilizer ingredients, the demand for which must necessarily vary according to the condition of soil, climate, the nature of previous cropping, etc., but the amount and proportions of the fertilizers used in these experiments approximately conform to general usage in market gardening.