Fertilizer Notes for Highland Vegetable Growing

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These notes were written in answer to queries from persons interested in growing vegetables in the Highlands, but they contain a great deal of general information on fertilizer choice and application. It is well to remember, however, that they were written for Highland conditions, and the comments on liming and fertilizer use have been directed at the acid clay loam soils with low phosphate availability that make up a very high proportion of Highland soils.

A FERTILE soil is one which provides all the essential nutrients to the plant as required. It follows that the fertility of a soil will depend not only on the essential nutrients being present, but also on their presence in a form available to the plant to meet the requirements for satisfactory growth and development.

Thus a nutrient element may be present in the soil, but unavailable to the plant due to its insolubility, or because it is in some way "fixed" within the soil structure. On the other hand, excessive quantities of an element may lead to toxic effects in the plant, or a deficiency of an element may result from an imbalance in the proportions of the essential nutrient elements present in the soil, with high concentrations of one element interfering with the uptake of another of relatively lower concentration.

Soil Reaction (pH)

Nutrient availability can be influenced by acid or alkaline reactions of the soil. In alkaline conditions, deficiencies of trace elements, manganese, iron, copper, zinc and boron can occur. Phosphorus deficiencies can be encountered in soils that are of moderate acidity, while strong acid soil reactions tend to be associated with reduced availability of calcium, magnesium, phosphorus and to a lesser extent, nitrogen, potassium, sulphur and boron.

Acidity and alkalinity are measured on the pH scale, which is a logarithmic measure. For ease of application, it can be considered as a scale of 14 points, with a midpoint of pH 7.0 representing neutrality, when the degree of acidity is exactly balanced by the degree of alkalinity. All measures below pH 7.0 represent reactions that are acidic, and those above pH 7.0 are alkaline. As the scale is logarithmic, changes in whole units represent tenfold changes in the degree of acidity or alkalinity. Thus a soil of pH 5.0 is 10 times more acid than a soil of pH 6.0, and a soil of pH 4.0 is 100 times more acid than one of pH 6.0.

The pH range 6.0 to 7.0 is the most favourable for the availability of nutrients to plants, but plant species vary in their preference for soil reaction, some being quite fastidious in this respect. This is indicated in the following table which shows the most favourable soil reaction recorded in literature for different vegetables.

Crop	pH Range	Crop	pH Range
Beans (French)	6.0-7.5	Onion	6.0-7.0
Beetroot	7.0-8.0	Parsley	6.5-7.5
Broccoli	6.5-7.5	Parsnip	6.5-7.5
Brussels Sprouts	6.5-7.5	Peas	6.0-7.5
Cabbage	6.0-7.0	Potato	4.5-6.0
Capsicum	5.4-6.8	Pumpkin	5.5-7.0
Carrot	6.5-7.5	Radish	6.5-7.5
Cauliflower	6.0-7.0	Rhubarb	5.5-6.5
Celery	6.5-7.0	Silver Beet	6.0-7.0
Cucumber	5.5-7.5	Spinach	7.0-8.0
Leek	7.0-8.0	Tomato	6.0-7.0
Lettuce	6.5-7.5	Turnip	5.5-7.0

Lime

Soil acidity can be reduced by application of lime in its various forms. Agricultural lime (ground limestone) which is predominantly calcium carbonate, is the safest form to use. Although it corrects acidity, it is not strongly alkaline, and it neutralizes the acidity very slowly over a period of time. This slow process, lasting some weeks or even months, is less likely to disturb the balance of other nutrients and induce deficiencies. Burnt and slaked lime are also used to neutralize strongly acid soils, but are not recommended for normal horticultural practice, as they are very alkaline in reaction and may have a deleterious effect on plants and roots.

The amount of agricultural lime required to correct unfavourable acidity will depend upon the pH of the soil, the type of soil, its organic content and buffering capacity, the fineness of the agricultural lime being used, and the annual rainfall. Heavy clays of pH 5.0 with high organic content may require three tons per acre of pulverized agricultural lime to raise the pH of the soil one unit to pH 6.0. However, a single application at this level may cause a "shock" reaction in the plant, and repeated dressings at a lower rate of application are generally recommended. Soil reactions in the Highlands region are frequently found to be in the range of pH 5.0 to 5.5, and recommendations of $\frac{3}{4}$ to $1\frac{1}{2}$ tons of lime per acre per annum (6 to 12 oz per square yard) depending on the pH, would not be considered excessive.

Overliming can induce deficiency disorders with leaf symptoms visually apparent. The correction of these disorders would require large applications of organic matter or alternatively dressings of sulphur or fertilizers containing sulphur such as sulphate of ammonia.

When correction of soil acidity is deemed necessary to obtain optimum vegetable production, it is preferable to apply the agricultural lime at least one month prior to field planting as some vegetables such as parsnips are sensitive to fresh applications. In this way the young seedling is given an opportunity to obtain some advantage from the corrected soil conditions at shallow depth early in its development, without the danger of lime reaction.

There is a tendency to regard lime solely as a soil ameliorant to reduce acidity and improve soil structure, and to overlook its importance as a source of calcium, an important and essential plant nutrient. While the quantity of lime necessary to reduce soil acidity may be very large, relatively small amounts of calcium are required to satisfy the nutritional needs of plants. Excess of calcium may restrict the uptake of potassium.

Dolomite

Dolomite or dolomitic limestone is similar to agricultural lime in its action. It contains magnesium carbonate as well as calcium carbonate and is preferred in some areas where magnesium is deficient.

Organic Manures

A prerequisite for successful production of vegetables is that the soil is well supplied with organic matter. Not only does the organic content provide necessary nutrients for adequate growth and development of crops, but it also contributes to, and maintains, favourable physical conditions of the soil.

Inorganic fertilizers (of mineral origin) may be utilized to provide or supplement the chemical needs of plants if soil fertility is inadequate, but by and large, inorganic salts have little or no beneficial effect on the physical properties necessary for a satisfactory plant-soil relationship. This does not mean that inorganic fertilizers are less important than organic manures. It simply means that a lack of organic matter may prevent the inorganic fertilizers from being fully effective.

The importance of the beneficial influence of organic matter on the soil should not be overlooked. It improves the texture of the soil, which in turn affects the exchange of air between the soil particles, the regulation of soil temperature and the effective growth of the microbial population. When the soil is lacking in organic matter, a surface crust is often formed. This restricts the movement of air, and the penetration of water into the soil. The surface crust can also be a barrier to emerging seedlings.

If the organic content of the soil is low, organic supplements in the form of animal manure, well-rotted vegetable refuse or compost should be applied and worked in. Alternatively, some practice of green manuring, entailing the production of a suitable cover crop should be adopted. Most of the manures of an organic nature, whether of animal or plant origin, contain nitrogen and phosphorus as well as smaller quantities of potassium, calcium, magnesium, sulphur and trace elements.

Green manures represent a cheap and effective method of improving soil fertility. Leguminous cover crops are of high value because of the ability of the associated rhizobium bacteria to take nitrogen from the air and convert it into a form which is readily assimilated by the plant; the cover crop, when turned in, has a relatively high nitrogen content. It is usually profitable to apply supplementary phosphorus and potassium fertilizers to promote more leaf growth as these elements will ultimately become available and benefit the following crop.

Inorganic Manures

For commercial production of vegetables the principal nutrients, nitrogen (N), phosphorus (P) and potassium (K) are generally supplied in the form of inorganic fertilizers and the method, rate and frequency of application is determined on the basis of the fertility of the soil and the requirements of the crop.

The soil conditions and requirements of a particular kind of vegetable must be considered in making a choice of fertilizer to obtain the most effective use. Thus the sensitivity to chlorides of beans, cucumbers, lettuce, onions, pumpkins, radishes and tomatoes should be taken into account if fertilizer dressings are to be applied. In soils known to be deficient in both potassium and sulphur, potassium sulphate would be preferred to potassium chloride (muriate of potash). In circumstances where both potassium and nitrogen additions are required, potassium nitrate may be preferred.

Nitrogenous Fertilizers

Nitrogenous fertilizers are available in many forms, but those most commonly used in the Highlands are urea and sulphate of ammonia. Both can have a deleterious effect if they come into contact with plant roots and leaves when applied in a concentrated form.

Urea has great value because it is a very concentrated form of nitrogen (46 per cent) and has little effect on soil reaction. Repeated heavy dressings of urea over prolonged periods on strongly acid clay soils, however, can lead to saturation of the soil colloids with ammonium ions and as a consequence induce deficiencies of other elements. Urea should not be used in soils of low sulphate availability unless elemental sulphur or a compound containing sulphur is applied to compensate for the low sulphur availability.

Sulphate of ammonia contains a little less than half the nitrogen content of urea (21 per cent) but it also contains sulphur. It is advantageous for use when both nitrogen and sulphur deficiencies may limit growth, but it has an acidifying effect on the soil. As with urea, frequent heavy dressings of sulphate of ammonia on acid clay soils over a prolonged period of time can lead to ammonium saturation of the soil.

Nitrate fertilizers are of great value as top dressings for rapid counteraction of nitrogen deficiencies when they become visible. The nitrate ion is very mobile and can be taken up by the plant easily, but by the same token, it can be easily washed out under conditions of high rainfall or sandy soil. Nitrate fertilizers are available as sodium nitrate (16 per cent N), potassium nitrate (13 per cent N), ammonium nitrate (34 per cent N), calcium ammonium nitrate (20 per cent N) and ammonium sulphate nitrate (26 per cent N). In recent years ammonium nitrate has gained wide acceptance as a rich source of nitrogen. It has a high ability to absorb water and because of explosive hazards which restrict its transport by aircraft, it is not recommended for use in the Highlands. In mixtures with chalk as calcium ammonium nitrate it has wide application overseas and has found useful application in the Territory on acid soils.

Phosphatic Fertilizers

Phosphatic fertilizers are available as water soluble phosphates such as superphosphates, ammonium phosphate and sodium phosphate. In these forms the phosphate is available to the plant in the young stage when the root system is developing. On acid soils with a high iron or aluminium content, however, the phosphate can form insoluble complexes which make the phosphorus unavailable to the plant. This problem can be overcome to a large extent by the use of di-calcium phosphate or rock phosphate, but transport costs preclude use of the latter in the Highlands.

Potash Fertilizers

Potash fertilizers are water soluble and are available as potassium chloride (muriate of potash, 50 per cent K), potassium sulphate (sulphate of potash, 41 per cent K, 18 per cent S) and sulphate of potash magnesia (Patent Kali, 22 to 25 per cent K, 5 to 8 per cent Mg and 15 to 20 per cent S). Potassium sulphate and Patent Kali are advantageous for sulphur-deficient soils, and for crops known to be sensitive to the chloride ion. Muriate of potash is cheaper if potassium only is required.

Mixed Fertilizers

While dressings of single fertilizers are ideal for correction of specific deficiency disorders, continued application of single fertilizers of the same type can lead to nutrient imbalance in the soil. To guard against this, fertilizer mixtures of varying composition can be obtained.

Mixed fertilizers may have varying proportions of N:P:K and may contain additives such as magnesium and trace elements. They are characterized by a high nutrient content, a uniform granulation and physical properties suitable for uniform distribution in the field. They may be obtained in a form free of chloride and containing sulphur if desired.

The initial choice of the most suitable complete fertilizer to use depends upon the soil fertility and nutrient needs of the crop to be grown. Where sulphur deficiencies occur, a fertilizer free of chloride and containing sulphur should be selected. Broccoli, beetroot, cauliflower, carrots, parsnip and rhubarb require a fertilizer with a higher percentage of potassium than nitrogen.

Application

Fertilizers may be applied in different ways. Frequently they are "broadcast" in which case they are spread evenly over the whole area to be planted. When only small quantities are involved or the space between rows is wide, or when soil fixation of phosphorus or potassium is likely, the fertilizer is often placed in bands. The fertilizer may be left as a top dressing on the soil, or it may be turned in. Because of the concentration of fertilizer in the band, care should be taken to ensure that there is no direct contact with the plant or its roots.

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The language used should be standard English with a minimum of technical terms. Technical words may be used, but should be explained the first time they are mentioned.

Photographs and diagrams should be included where applicable. Black and white photographs should be 6 in x 8 in glossy prints. Negatives will be accepted if prints cannot be obtained. If black and white photographs are not available, coloured slides may be submitted to see if black and white prints can be made from them.

All articles are submitted to the Editorial Committee for approval before publishing.

NEW TRAINING SCHOOL

THE facilities for livestock training have been expanded with the conversion of the Livestock Station at Bisianumu into a livestock training school for farmers, and for field officers of the Department, such as Livestock Assistants and Rural Development Assistants. Three courses will be run each year, and initially there will be 24 trainees at each course. A livestock officer, Mr P. Long, is Officer-in-Charge of the school.

Similar training courses are already operating at the other livestock training schools at Erap, Baiyer River and Urimo. These four schools have places for a combined total of 178 trainees at each four-month course.

Enrolment at courses is processed through Regional Rural Development Officers who notify District Rural Development Officers of the places available to them for each District.