**Communica: Message From Webserver to Hostserver.**

**X**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | This webpage is loading. Please hold. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

|  |  |
| --- | --- |
| |  | | --- | |  | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | |  | | | |  |  |  | |  | |  | |  | |  | |  | |  | |  | |  | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **introduction**   * [Why not use a multipurpose fertilizer and avoid trouble?](#30j0zll) * [Types and Forms of Soil](#1fob9te) * [Neutral Growth Mediums](#3znysh7) * [A Crash-Course In Soil Amendments](#2et92p0) * [Basic Plant Nutrition](#tyjcwt)   + [The Macronutrients](#3dy6vkm)     - [Nitrogen](#1t3h5sf)     - [Phosphorus](#4d34og8)     - [Sulfur](#2s8eyo1)     - [Potassium](#17dp8vu)     - [Magnesium](#3rdcrjn)     - [Calcium](#26in1rg)   + [The Micronutrients](#lnxbz9)     - [Chlorine](#35nkun2)     - [Nickel](#1ksv4uv)     - [Copper](#44sinio)     - [Iron](#2jxsxqh)     - [Manganese](#z337ya)     - [Zinc](#3j2qqm3)     - [Boron](#1y810tw)     - [Molybdenum](#4i7ojhp)     - [Cobalt](#2xcytpi)   + [Table 1: Symptoms of Excess or Deficiency of Nutrients](#1ci93xb) * [Why the Radish?](#3whwml4)   + [Table 2: Recommended Fertilizer Rates for Radishes](#2bn6wsx) * [Why is this Research Important?](#qsh70q) * [Question](#3as4poj)   [**top**](#gjdgxs)  **Why not use a multipurpose fertilizer and avoid trouble?**    Every type of plant requires a special nutrition. There are many multi-purpose fertilizers that can be used to feed plants at mass, but once a little investigation is done, most come across a quandary. There are an exorbitant amount of these combination fertilizers, some for specific flowers, vegetables, fruit trees, and other types of plants. There are even more choices and differences in these subcategories, so the question remains, what fertilizer do you choose? Large-scale farmers who produce crops in mass rely on the research of scientists and their own experiences to choose the correct proportions of nutrients in order to protect their investment and have a high crop yield. Their own livelihoods are usually at stake, as well as the macroeconomic implications of a low crop, including high prices and decreased supply. This investigation into plant nutrition is aimed to help answer one of these concentration questions, specifically, the relationship between Potassium, Magnesium, and Calcium, three major nutrients in soil, and a common late winter-grown vegetable.    [**top**](#gjdgxs)  **Types and Forms of Soil**    Soils can be differentiated based on the characteristics of their non-living elements. Soil scientists describe soil types by their texture; in common terms, how much sand, silt, and clay is present. Three main soil types are commonly discussed: clay, silt, and sandy. Clay soil is small sized non-living particles creating highly dense soil. It is smooth when dry and sticky when wet. Soils high in clay content are considered to be heavy soils. Silt is smooth, powdery, medium sized, and creates medium density soil; when wet it is smooth but not sticky. Sandy soil is made of large sized non-living particles, creating a low-density soil. When you rub it, it feels rough, as it has sharp edges. Sand doesn�t hold many nutrients because the soil is so porous.  The type of soil used is important, because each type has a different ability to transfer nutrients and water to the plant�s root system. For example, the relatively high density of clay soil allows it to retain water, which might be beneficial during a drought, but harmful during a wet season to a plant that requires little water. Clay soil retains nutrients better than other types, which is good for plants that need a lot of nutrients, but bad for those that cannot handle over-exposure. Sandy soil�s relatively large sized particles means that both water and nutrients can drain away, which is good for plants during a rainy season and harmful for plants during droughts. *(10)*    [**top**](#gjdgxs)  **Neutral Growth Mediums**    For the experiment, a neutral soil with no included nutrients was needed to prevent inaccurate data. There are two options in this situation: perlite and vermiculite. Perlite is formed by superheating volcanic ash, causing it to expand. It is very light weight and is often used in potting mixes to encourage good drainage, as well as to keep the soil from compacting. Because it is porous, it helps to maintain good soil moisture. Its size ranges, but it is about as large as standard gravel.*(15)* However, it would allow the nutrients to leech. So vermiculite, a member of the phyllosilicate group of minerals that resembles mica, is the better choice for this research.*(12)* Vermiculite is the mineralogical name given to hydrated laminar magnesium-aluminum-ironsilicate (the chemical formula is (Mg,Ca,K,Fe11)3 (Si,Al,Fe111)4O10(OH)2O4H2O). Vermiculite is found in various parts of the world, but the predominant commercial mines are in Australia, Brazil, China, Kenya, South Africa, USA, and Zimbabwe; vermiculite is mined by open pit methods.*(14)*  Vermiculite is well established as a growing medium, as the presence of vermiculite particles allows for aeration, improved retention, and the promotion of a steady release of added fertilizers.*(12)* There are two types of vermiculite: untreated and exfoliated. Untreated vermiculite is a dark brown color while exfoliated vermiculite is lightly colored. Exfoliated vermiculite is that has been expanded by rapid heating. Untreated vermiculite is commonly used as an active component of wall plasterboard. The exfoliated product is used extensively as a lightweight aggregate in fireproofing, thermal insulation, acoustical plasters, horticultural growth media, and as a fertilizer carrier.*(13)* The exfoliated vermiculite has a pH in water of between six and nine. It carries no nutrients, so it is necessary to add soil amendments to supply nutrients. For the experiment at hand, exfoliated vermiculite is the best choice.    [**top**](#gjdgxs)  **A Crash-Course In Soil Amendments**    Fertilizers are commonly distinguished by a series of three numbers that are called the NPK ratio. This meter indicates the three macronutrients that have the highest concentrations in the soil: nitrogen, phosphorus, and potassium. All fertilizer components that carry any three of these elements have this ratio placed somewhere on their container. For example, a good multipurpose fertilizer has a ratio of 10-5-10, or 10% nitrogen, 5% phosphorus, and 10% potassium. This is not to be confused with the three-numbers used later in the data, which stands for the gram amounts of potassium, magnesium, and calcium per liter of vermiculite.  There are many types of soil amendments that add various nutrients into the soil. Blood meal is an organic fertilizer that is very high in nitrogen (13-0-0) and is very soluble in water, unlike most dry organic fertilizers. All this together means that its effect is strong and quick, but its power will only last a short while, especially in wet weather. Blood meal can easily burn a plant's leaves and contains plant growth regulators. Fishmeal is also high in nitrogen, but its NPK ratio is generally more potent in K and P, at somewhere about 5-3-3. For this experiment, blood meal is the standard source of nitrogen. Bone meal is an organic fertilizer that is applied to increase phosphorus levels in the soil. Although rock phosphate can also be used for this, bone meal will break down in the soil considerably faster and can thus be used as a quick fix; this also means that it will not have a long-term effect on the soil. Rock phosphate is slow to dissolve in water, so adding it will benefit the soil over a period of years. The phosphate found in many synthetic fertilizers is usually the rock form treated with sulfuric acid to make it more soluble and more readily available to plants; this form is called super-phosphate.  A common source of calcium is ground up calcium carbonate or limestone, commonly called lime. Ground lime is readily dissolved into the soil where it reduces soil acidity by releasing calcium cations. Calcium is also available in liquid solution, usually derived from calcium acetate. Potash broadly describes any material containing potassium. More specifically, though, potash is potassium carbonate derived from wood ash. The term potash comes from the process of extracting lye from wood ashes in iron pots.� Gypsum, which occurs naturally in sedimentary rocks, is a dry organic fertilizer that supplies two important micronutrients: calcium and sulfur. Manure is rich in nitrogen (especially chicken, goat, and steer manures), and is thus a valuable component of compost. It is also rich in potassium and phosphorus. Manure should be composted (or at least aged) before use in the garden because of its high nitrogen and ammonia content, which can both easily burn plants in high concentrations. However, it would be difficult to vary the concentrations of potassium, phosphorus, and nitrogen if they were all in the base fertilizer. So manure was not used in the investigation.*(15)*    [**top**](#gjdgxs)  **Basic Plant Nutrition**    Plants require an abundance of minerals and elements to grow and function correctly, as do any living organisms. Elements that are needed by plants in large quantities are called macronutrients and include Nitrogen, Potassium, and others. Minerals that are needed in minute amounts are called micronutrients. Carbon, Hydrogen, & Oxygen are drawn into the plant through water and carbon dioxide, and even though they are necessary macronutrients, they do not apply to the research at hand.    [**top**](#gjdgxs)  *The Macronutrients (1-2)(7)*    [**top**](#gjdgxs)  **Nitrogen**: Probably the single most important nutrient for a plant to have, Nitrogen is needed to construct nitrogenous bases for DNA and RNA and the amino acids needed for protein synthesis. It is also a component of many coenzymes and hormones. Nitrogen is obtained by a plant through the compounds NO3 and NH4; some plants, such as legumes, have nitrogen-fixing bacteria in root nodules that take atmospheric nitrogen and make it available to the plant.    [**top**](#gjdgxs)  **Phosphorus**: Like Nitrogen, Phosphorus is needed by a plant for nucleic acids and protein, but it has many other uses. Phosphorus is a component of the phospholipids that construct both the plasma membrane and many internal membranes, and forms the inorganic phosphate groups that form the energy section of ATP. Several coenzymes used within the plant�s metabolism also require phosphorus. The element is absorbed through the compounds H2SO4 and HPO4, and does not leech from the soil, as it is fixed to Iron, Magnesium, and Aluminum under acidic conditions and Calcium under alkaline conditions.    [**top**](#gjdgxs)  **Sulfur**: One of the lesser macronutrients, Sulfur is only used by plants for proteins and coenzymes. It can be absorbed, like magnesium, through the roots of the plant as SO4, and through the leaves of a plant as common air pollution. Because it can be drawn from the air, sulfur is almost never deficient.    [**top**](#gjdgxs)  **Potassium**: Absorbed as its ion K+, Potassium is a cofactor in protein synthesis and is a major player in the regulation of water balance. Due to this ability, it is used by a plant to open and close its stomata. Higher concentrations of potassium promote the growth of reproductive organs, specifically, flowers and fruit, while lower concentrations promote the growth of vegetative portions of the plant.    [**top**](#gjdgxs)  **Magnesium**: Magnesium is required for the activation of many enzymes and for the synthesis of chlorophyll. It is absorbed as its primary ion, Mg++, and can be absorbed through both the roots and leaves of a plant. The most common sources of Magnesium are dolomitic limestone and Epsom salts.    [**top**](#gjdgxs)  **Calcium**: Required for the formation and stability of a plant�s cell walls and the maintenance of both the structure and permeability of cellular membranes. It also activates certain enzymes and regulates cell responses to various factors. High concentrations of Ca++ cause an abnormally high pH inside the plant; over or under-watering can have an adverse effect, as the calcium is swept away in solution.    NOTE: Potassium, Magnesium, and Calcium are unlike any of the other nutrients, as they are all connected to one another. A deficiency or excess in one causes problems with the other two, so it is completely necessary that these three be in fairly good balance to prevent disease or damage to the plant.    [**top**](#gjdgxs)  *The Micronutrients (1-2)(7)*    Plants also need some minerals in trace amounts to aid in various cellular processes, just as humans and animals do. Although usually overlooked, the micronutrients are as necessary to plant growth as any of the macronutrients. Most all-purpose fertilizers carry trace amounts of these nutrients, and since they do not leech completely though the soil, they tend to remain for a long period of time. In fact, deficiencies in the micronutrients are fairly rare if the soil is in good growing condition and is at a consistent neutral pH.    [**top**](#gjdgxs)  **Chlorine**: Used as a water-balancer and is used in the water-splitting step of photosynthesis    [**top**](#gjdgxs)  **Nickel**: Aids an enzyme that metabolizes nitrogen    [**top**](#gjdgxs)  **Copper**: Component of many enzymes    [**top**](#gjdgxs)  **Iron**: Part of the electron transport chain, activates some enzymes    [**top**](#gjdgxs)  **Manganese**: Helps form amino acids, activates some enzymes, required by water-splitting step of photosynthesis    [**top**](#gjdgxs)  **Zinc**: Active in formation of chlorophyll, activates enzymes    [**top**](#gjdgxs)  **Boron**: Aids the synthesis of chlorophyll    [**top**](#gjdgxs)  **Molybdenum**: Aids in nitrogen fixation    [**top**](#gjdgxs)  **Cobalt**: Aids in nitrogen fixation      [**top**](#gjdgxs)  *Table 1: Symptoms of Excess or Deficiency of Nutrients (1-2) (3)*   |  |  |  | | --- | --- | --- | | **Nutrient** | **Symptoms of excess** | **Symptoms of deficiency** | | Nitrogen | Dark green color; weak spindly growth; few fruits; brittle growth | Reduced growth; yellowing (chlorosis); reds and purples may intensify | | Phosphorus | Micronutrient deficiency of Zn, Fe, or Co | Reduced growth; color may intensify; browning or purpling; reduced flowering | | Potassium | Causes N deficiency | Reduced growth; shortened internodes; brown leaf edges & dead spots in leaf; tendency to wilt | | Magnesium | Interferes with Ca uptake | Reduction in growth; marginal & interveinal chlorosis; reduction in seed production | | Calcium | Interferes with Mg absorption | Stunted growth; death of roots; blossom rot; black spots on leaves and stems | | Sulfur | Sulfur excess is usually in the form of air pollution | yellowing of plant; light green color | | Iron | Interveinal chlorosis | Pale leaves; chlorosis | | Boron | Failure to set seed | Brown, discolored, cracked, fruits, tubers and roots; death of vein tissues | | Zinc | reduction in size of leaves; short internodes | Appears as Fe deficiency; interferes with Mg absorption | | Copper | New growth small & misshapen | Shows up as Fe deficiency; brown spots | | Maganese | Interveinal chlorosis of leaves followed by brown spots | Reduction in growth, brown or black spots | | Molybdenum | None | Interveinal chlorosis; pale leaves | | Chlorine | Wilted leaves which die | Wilting stubby roots; yellowing & bronzing; leaf burn | | Cobalt | Little known | Nitrogen deficiency |       [**top**](#gjdgxs)  **Why the Radish?**    Radishes are a minor crop in the world (for example, in the entire state of Ohio, there is only 28 growers of radishes)*(5)*, not used as a staple by any means, but still used widely throughout many cultures. Its root, the edible portion of the plant, is commonly used as a garnish for salads and other dishes, as well as a major component of hors d�oeuvres and appetizers. The radish was not the original intention of this investigation, but there are few vegetables as hardy as the radish during the winter months. They germinate in soil in four to six days and harvest in twenty-five days on average; as a late winter crop, they require lots of water to support rapid growth. They have the ability to grow in a wide range of soils but do best in a light mineral or mucky soil *(6)*. There are multiple varieties or radishes from different areas of the world, including standard red belles, oriental Lo Bok, and dikon radishes *(4)*; the ones used in this experiment are �sparkler� radishes, a common variety that has a half red half white root and a peppery flavor.    [**top**](#gjdgxs)  *Table 2: Recommended Fertilizer Rates for Radishes (6)*   |  |  | | --- | --- | | **Nutrient** | **Amount** | | Nitrogen | 130-150 lb/acre | | Potash (K) | 100-150 lb/acre | | Sulfur | 30-50 lb/acre | | Boron | 1-5 lb/acre |       [**top**](#gjdgxs)  **Why is this Research Important?**    Why would this research be important? Although radishes are not a major crop in the nation and in the world, they may be important in crop rotation practices for farmers, especially if they want to grow a crop during the late winter when. If a farmer plants a vegetable and fails to place the correct proportions of fertilizers, he may lose thousands of dollars in labor, seed, herbicides, and soil supplements. A radish, although a hardy plant, is no different. The correct proportion of elements and compounds in the soil is necessary for proper growth. Magnesium, Potassium, and Calcium, as the only three macronutrients that affect one another, are especially important since radishes require a large amount of potassium compared to other nutrients. The goal of this investigation is to discover the concentrations of these three macronutrients that provide the radish plant with the greatest growth.        [**top**](#gjdgxs)  **Question**  What is the optimal concentrations of potassium, calcium, and magnesium, that allow for the most favorable growth for radishes? | | | | | |