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|  | We often hear about how important it is that we maintain a balanced diet with all the essential vitamins and minerals, but do we ever consider the diet of our plants? As we become increasingly concerned with problems such as the environment and food shortages, one can't help but wonder if using such vitamins and minerals as a type of organic fertilizer might not only help the environment, but also increase our food production rates as well. Is there a certain " magical " vitamin or mineral that when fed to plants will increase their growth rate ?  "Because so much farmland in America is deficient [of needed nutrients ], the framer is under tremendous pressure to buy chemical fertilizers," notes Nancy Bubel In Organic Fertilizers: Which Ones and How to Use Them. However, while chemical fertilizers may increase crop output, they often have a damaging effect on the environment. Rain can cause fertilizers to run off into an area's watershed. Run off not only harms the area's water supply and the creatures who depend on it, but it also diminishes the effectiveness of the fertilizer. Also, our increased dependence on chemical fertilizers has disrupted the earth's nitrogen cycle, resulting in a loss of soil nutrients, a raise of acids in lakes and rivers, and increasing the greenhouse effect. Of course, fertilizers are not the only cause of these problems; increased burning of fossil fuels among other factors have contributed to the problem as well. However, a recent study done by ecologists at Stanford University " identifies as the chief culprit the industrial fixation of nitrogen gas to make fertilizers."( Beardsley 24 ) Therefore, finding an alternative to chemical fertilizers is essential in order to preserve our atmosphere. While alternatives do already exist in forms of organic fertilizers such as potash, many people are unaware which ones to use and are discouraged by the high prices of organically grown foods. However, it may be possible that by simply adding an important vitamin or mineral you could effectively, and inexpensively, stimulate plant growth without harming the environment.  In this experiment, I plan to grow radishes and feed them selected vitamins and minerals to see if their growth rate is increased by the added nutrients. Radishes were chosen because they mature quickly. The minerals and vitamins used were selected for varying reasons that will be discussed later.  Research  Radish Background  Radishes ( Raphanus Satius ) belong to the mustard family ( Brassicaceae Genus ) and are closely related to the cabbage, cauliflower, and turnips. It is believed the radish originated from China and later spread to middle Asia. Greek writing reveals that radishes were also important to their ancient culture. Small golden replicas of radishes were produced and offered as gifts to the god Apollo. The Romans later introduced this vegetable to the Germans. The radish continued to spread throughout Europe, and by 1548 radishes had reached England. They arrived in the New World and were first cultivated in Massachusetts in the early 1600's.  Although many different varieties of radishes such as the Cherry Belle, the Early Scarlet Globe, and the Red Boy exist, in this experiment Sparkler White Tipped radishes will be used because they take the least time to reach maturity. Most radishes take 3-6 weeks to fully develop and should be grown in between the months of March and May. Winter varieties of radishes such April Cross and Long Black Spanish do exist, but they tend to have longer roots than regular radishes and take twice as long to grow. The Sparkler white tip seeds take 3-10 days to germinate and are ready for harvest in 35 days. Rapid growth is best for radishes because it insures they remain mild and tender. Slow growing radishes are tough and less attractive.  Disease control is seldom necessary for radishes. In fact, radishes are used to protect other plants from predators. Radishes are often planted close to onions and potatoes to distract root maggots.  Vitamin and Mineral Background  Since the 1700's scientists have realized scurvy could be prevented by consuming large quantities of fruits and vegetables. Sailors who were most likely to get the disease would often prevent this by sucking on limes. Little did they know that it was the Vitamin C ( also known as L-asorbic acid ) present in limes that helped prevent the disease. However, investigation of the vitamin was largely ignored until 1902 when Holst discovered that guinea pigs often suffered from a deficiency of Vitamin C in their system. Thus, the guinea pig became the first animal involved in Vitamin C experiments which is fortunate because Vitamin C is only essential to the diets of a few animals, including guinea pigs, humans, the Indian fruit bat, and certain types of birds and catfish. However, Vitamin C was not isolated from lemons until 1932 by Waugh and King. The biochemical importance of Vitamin C was discovered about 1925 when it was found that asorbic acid was essential to oxidation reduction actions in plants and animals. Oxidation of Vitamin C leads to the loss of hydrogen and the formation of dehydroascorbic acid. Most recently, in 1975, redox reaction of asorbic acid were discovered to activate electron transport chains, thus leading to the formation of ATP which provides animals and plants with energy.  McCollurn and Davis and Osborne and Mendell in 1913 and 1915 noted that an "accessory" growth factor found in fats was necessary to the growth of rats. The "fat - soluble A factor" was later named Vitamin A after Harren discovered its structure in 1931. Although all vertebrates require Vitamin A to live, plants do not contain it. However, plants do contain carotenoids like beta-carotene which when split in half form 2 Vitamin A. Vitamin A is best known for its effect on human sight. When Vitamin A is oxidized it is converted to a retinal pigment which effects the rods and cones of the human eye.  Magnesium ( Mg ) is a natural occurring element/mineral in the earth. It makes up about 2.1% of the earth's crust and is a major component of energy transferring enzymes. Magnesium plays a key role in the formation of ADP and ATP. In the Kreb Cycle, Magnesium helps to convert ATP back into ADP. Magnesium stabilized ATP is made during oxidative phosphorylation. In addition, magnesium serves as an activator for phosphorylation in glycolisis and is found in the center of all chlorophyll molecules.  Potassium ( K ) is also a natural occurring element that makes up 2.6% of the earth's crust. In humans, it is essential to the nervous system. Potassium ions are also known for their roll in active transport across cell membranes and for driving pumps that generates ATP. ATP provides energy for all living things, and is necessary for the survival of both plants and animals.  Plant Hormones:  Although ATP production is imperative to plant survival, growth could not occur without plant hormones. The exact function of plant hormones is largely unknown and many overlap in function. Their effect on plants may vary depending upon plant age, environment, and nutrition. However, the general function of some plant hormones are known.  Auxin effects over all plant growth, especially cell differentiation and division. It is believed this hormone may increase transcription rates of RNA and effect movement across cell membranes. Auxin is also responsible for leaf shedding. Finally, auxin encourages fruit and crop production by increasing the rate of ripening and stimulating root growth.  Fruiting stages of plants are set by gibberellins. This hormone also helps plants to absorb nutrients from the soil and increase the absorption rate of potassium. However, probably most impressive is that gibberellins can produced full sized plants from dwarf versions of that plant.  Cytokins exact actions are unknown but they are believed to effect the DNA of plants as they provided cell structure. They also appear to play a roll in cell division.  Abscisic acid is a hormone that usually has a growth inhibiting effect. It induces dormancy and contributes to dwarfism. However, it does occasionally enhance fruit production.  Criteria for Selected Vitamins and Minerals and Their Role in Plant Growth  \* Potassium - According to Nancy Bubel in Organic Fertilizers: Which Ones and How to Use Them " root and tuber crops require enormous amounts of potassium." This is due to the important role potassium plays in plants. It carries carbohydrates through the plant and aids in the production of sugars, starches, and oils. Potassium is required for the opening and closing of stomata in plants which is necessary for efficient water use, and, in some cases, potassium actually reduces water use. This mineral is essential to cell division and plant growth and is used in large quantities by plants when they are in a stage of rapid growth. These benefits illustrate why potassium makes up over 70% of an organic fertilizer known as potash which encourages root growth and increase plant growth. However, usually only about 2% of the potassium present in the soil is available to crops, so feeding radish more potassium could potentially increase their growth rate.  \* Magnesium- The second mineral, magnesium, was selected because " radishes are highly responsive to magnesium." ( Bubel 38) The three most essential minerals to plant growth are potassium, phosphorus, and magnesium. Magnesium has a significant role in plant development because it is present in all chlorophyll molecules without which photosynthesis, and plant growth, could not occur. This mineral also activates enzymes required in the growth process and helps to balance out excessive levels of nutrients in the soil. An introduction of extra magnesium to the soil could stimulate faster plant growth.  \* Vitamin A - Vitamin A, a fat soluble vitamin, is extremely photosensitive and undergoes rapid oxidation. This vitamin was selected because it has a structure similar to that of the plant hormone absicisic acid with a side group of CH3 as well as an end ring containing 3 CH3 . Although this hormone often has a dormitory effect on plants, it is believed to increase fruit/ vegetable production; thus it could potentially stimulate radish growth.  \* Vitamin C- This vitamin, also known as asorbic acid, is a weak acid easily destroyed by alkalis. While it is easily oxidized, it does prevent the oxidation of water soluble molecules as well as fat soluble vitamins such as Vitamins A and E. Even though Vitamin C is most easily oxidized by oxygen, oxidation and the rate of oxidation are also increased by high levels of copper and zinc. Oxidation is executed directly by an enzyme known as asorbic acid oxidase and indirectly by peroxidase enzymes. Peroxidase enzymes are abundant in plants and cause the levels of Vitamin C in the tissue to drop. This is significant enough to suggest that adding Vitamin C to the soil could replace the oxidized Vitamin C and possibly effect the growth rate of radishes. |

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