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|  | |  |  |  | | --- | --- | --- | | |  |  | | --- | --- | | INTRODUCTION/Literature Review  What do plants need to grow? "Light, air, water, and space for roots," says Sunset Western Garden Book, in addition to a constant supply of nutrients "necessary to carry out their life processes." (1). But why aren�t these elements available in everyday soil? They are, but not always in the right amounts, and that�s why gardeners invest so much money in the right types of fertilizer and soil. So far, so good, but there so many hundreds of fertilizers to choose from! Which works the best for a typical, quick-growing garden plant like the sweet pea? That was our question when we began this investigation, a simple look at what�s essential to plant growth through observing our local creek soil, a mixture called Supersoil, and five commercial fertilizers: Miracid, Kelp Sea Life, Fish Emulsion, Jobe�s Plant Food Spikes, and Super Plush Lawn Food.  SWEET PEAS  We chose sweet peas as our experimental plant primarily because it is a hardy, rapid-growing, flexible plant, as well as having the colorful and sweet smelling flower it is known for.  **The Basics**  The genus *Lathyrus* includes some 150 species of annuals and perennials that inhabit sunny, grassy wastelands or open woodlands in north temperate regions, north and east Africa, and temperate South America. The basic sweet pea, of the species *Lathyrus odoratus*, is a spring or summer flower with a fresh, sweet fragrance and clusters of blooms in varying colors, including deep rose, blue, purple, scarlet, white, cream, amethyst on white ground, salmon, and salmon pink on cream. (2). It is an annual climber, easily growing to 5 feet and more, with "winged stems and mid to dark green leaves comprising a pair of ovate-elliptical leaflets."(3). Each flower has one large, upright, roundish petal, two narrow side petals, and two lower petals, forming a boat-shaped structure. (4). It is fond of plenty of sunlight, but does well in half-shade, too, and succeeds in most moderately well-drained soils. These properties along with the sweet pea�s relatively rapid growth are what led us to choose sweet peas for our experiment.  **Bacterial soil symbiote**  This species of plant has a symbiotic relationship with a certain soil bacteria, called nodule bacteria or *Rhizobia*, which helps the sweet pea to obtain nitrogen by living on its roots and fixing nitrogen from the soil atmosphere (5). In turn, the bacteria obtain their energy from the host plant. These bacteria are excellent supports for the sweet pea, because plants do not readily obtain nitrogen through the soil unless it is combined with hydrogen or oxygen, a process called nitrogen fixation. This usually only occurs through lightning, occasional nitrogenous groundwater, or the help of soil organisms that extract nitrogen from the air between soil particles. Having the bacteria actually attached to the roots gives the plant far more nitrogen than it would receive from free-living bacteria or other sources.  **History**  The sweet pea is a native to Sicily and southern Italy, and it was discovered in 1699, bearing only petals of purplish maroon, by a Sicilian monk named Franciscus Cupani, who found its color and fragrance delightful enough to send seeds to colleagues in various countries. The flower attained little acclaim, however, until Henry Eckford bred the grandiflora strain with larger flowers in a wide range of colors, resulting in a new variety with a far greater ornamental value but the same lovely scent. (6).The flower is still popular enough today to uphold organizations such as the National Sweet Pea Society, a group based exclusively upon the research and cultivation of this plant.  **Fun Facts**  **-** The name "sweet pea" is believed to have first been used by the poet Keats (1795-1821).  **-** The sweet pea�s present name, *Lathyrus odoratus*, was the name chosen by the Swedish naturalist Linnaeus to replace the former, less memorable, but highly descriptive *Lathyrus distoplatyphyllus, hirsutus, mollis, magne et peramaeno flore, odoro* given to it in 1701 by Caspar Commelin*.*  **-** Market research consistently finds sweet peas to be one of the top three favorite flowers in the UK.  **-** Sweet peas are not edible, being somewhat poisonous if eaten in quantity.  **-** Fresh flowers in the house have been shown to improve general wellbeing, boost both male and female libido, and lessen the effects of a hangover.  ~ Owl�s Acre Sweet Peas, http://www.webgarden.ndirect.co.uk/trivia.htm  SOILS  Having a great desire to see, first-hand, the quality of the soil along the banks of our local creek, the Arroyo Del Valle, we will compare the clay-like loam of the creek to a high-quality Supersoil, rich and nutritionally balanced for gardening. It would seem that those plants enjoying the Supersoil would grow far better in this experiment, but it will be interesting to see the results nonetheless. One wonders, at least, what the physical differences will be between the plants grown in such vastly different mediums.  **Physical Properties of Soil**  Because the creek soil is clay and silt-like, we will outline the properties of clay and silt soils.  Clay soils "are generally rich in potential, but unavailable, plant nutrients."(7). They consist mostly of aluminum oxides and related compounds, and are so finely ground that they may become impenetrable to moisture and air, which impedes plant growth, because so much of a plant�s nutrients come from air and water.  Silt is halfway between sand and clay, and is typically found along creek beds, which may make it a likelier candidate for the composition of our creek soil. Being near a stream, it has been deposited in layers due to the action of the water, and therefore is likely to contain "humus," or decomposed animal and plant matter. Silt is a better planting medium, since it is between sand and clay, and to improve clay soil, one adds sand.  FERTILIZERS  Gardeners add fertilizers to their plants in order to supply additional nutrients which may be unavailable in the soil. In general, plants need macronutrients, meaning those elements that are necessary in large amounts, and micronutrients, which are needed in such small quantities that plants can usually obtain them through most soils. Interestingly enough, "94-99.5% of fresh plant material is made up of carbon, hydrogen, and oxygen,"(8) elements which are available from air and water. It is only the remaining 0.5-6% that is supported by other nutrients found in soil or fertilizers, yet these are essential to plant growth.  *Essential Plant Nutrients*  **Supplied by air and water Macronutrients**, supplied by soil/fertilizer **Micronutrients**, supplied by soil/fertilizer  Carbon (C) Nitrogen (N) Zinc (Zn)  Hydrogen (H) Phosphorus (P) Copper (Cu)  Oxygen (O) Potassium (K) Iron (Fe)  Sulfur (S) Manganese (Mn)  Calcium (Ca) Boron (B)  Magnesium (Mg) Chlorine (Cl)  Cobalt (Co) Molybdenum (Mo)  ~ Alberta Agriculture, Food, and Rural Development (www.agric.gov.ab.ca/crops/cer-fertnutrit.html)  **Nitrogen**  The most commonly deficient element is nitrogen, because it "is not a mineral and hence is not present in the minute particles of soil" (9) from which plants derive their other essential elements. All nitrogen must come, therefore, from other sources, such as organic matter, air, water, and of course, fertilizers. (That is why nitrogen is such an essential part of most fertilizers: it is the most likely to be needed by the plant.)  Plants take up nitrogen primarily in the form of nitrate or ammonium ions, but mostly in the nitrate form. This is because nitrate is soluble and moves with water, which is easily taken in by plant roots, whereas ammonic nitrogen is bound to the surfaces of soil particles and cannot move to the roots. (10). Also, soil organisms, such as the afore-mentioned *Rhizobia*, change all forms of nitrogen fertilizer to nitrate before the plant absorbs it. Therefore, fertilizers containing mostly nitrate nitrogen will allow the plant access to the nitrogen right away, but fertilizers containing ammonic nitrogen will have to be converted into nitrate and will take longer to reach the plant.  Plants use nitrogen to form essential proteins, chlorophyll, nucleic acids, and the enzymes needed for their cells to live and reproduce. Nitrogen deficient plants will show the following symptoms: 1) slow or stunted growth, 2) a yellowing of the plant from the bottom upward, and 3) yellowing leaves from the tips toward the stem. This yellow-green color is called chlorosis, and is usually more pronounced in older tissue because nitrogen moves from older to younger tissue when it is in short supply. (11).  **Phosphorus**  Phosphorus availability is low in most soils, and the compounds in which it is contained tend to have limited solubility, although solubility is strongly affected by soil temperature and pH. Maximum availability of soil phosphorus occurs at pH 6.5 to 7.5. (12). Incidentally, research has shown that plants tend to absorb greater amounts of phosphorus when it is applied along with the ammonium form of nitrogen. This could be because the nitrogen increases root growth, which may substantially increase transfer of phosphorus across the root to the xylem, or it could be due to the lowering of soil pH caused by the additional nitrogen.  Plants use phosphorus, an element present in all living cells, to form nucleic acids and to store and transfer energy through ATP. Phosphorus stimulates early growth, root formation, and seed production. Symptoms of phosphorus deficiency are 1) slow growth, 2) purplish coloration on the foliage, 3) dark green coloration with dying tips of leaves, 4) delayed maturity, and 5) poor grain, fruit, or seed development. (13).  **Potassium**  Potassium is often described as "water-soluble potash" or "available potash" when it is included in complex fertilizers. Plants remove from the soil more potassium than any other nutrient except nitrogen and calcium.(14). Although potassium exists in soil in several forms, only about 1% of that is available to plants.  Potassium is essential for the translocation of sugars, for starch formation, and for the opening and closing of stomata, encourages root growth, and produces larger xylem vessels throughout the root system. Symptoms of potassium deficiency are 1) slow growth, 2) weak stalks, and 3) small fruit or shriveled seeds.  **Calcium, Magnesium, Sulfur**  Calcium is an essential part of cell wall structure and must be present for the formation of new cells. However, it tends to be relatively abundant and usually is only needed as a fertilizer requirement in very acidic soils. Signs of calcium deficiency are 1) death of terminal buds and root tips, 2) abnormal dark green foliage, 3) premature shedding of blossoms and buds, and 4) weakened stems. (15).  Magnesium is essential for photosynthesis because the chlorophyll molecule contains magnesium. This element also acts as an activator for many growth enzymes. Although magnesium content is generally high in western soils, there is more often a magnesium deficiency than calcium. Sandy soils tend to be deficient in magnesium. Symptoms of deficiency are 1) yellowing of older leaves, and 2) curling of leaves along the margins.  Sulfur, in addition to being absorbed from soils and fertilizers, may be absorbed from the air in areas where industry has enriched the atmosphere with sulfur compounds. Sulfur is essential for protein synthesis, nodule formation on legume roots, and oil compounds found in plants such as garlic and onion. Symptoms of sulfur deficiency include 1) light green to yellowish leaves, 2) small, spindly plants, and 3) slow growth and delayed maturity.  **Iron, zinc, manganese, molybdenum**  These nutrients are micronutrients: the plant only needs very small amounts, yet they are essential for growth. However, because they are only needed in such tiny quantities, there�s very little difference between sufficient and toxic.  Iron is required for the formation of chlorophyll, and helps to activate respiration, photosynthesis, and symbiotic nitrogen fixation. Symptoms of iron deficiency are 1) yellowing of the leaves, 2) twig dieback, and 3) in severe cases, death to entire limbs or the entire plant.  Zinc takes part in several important enzyme systems, and helps to regulate plant growth, so terminal growth areas are affected first if a plant is zinc deficient. Signs of zinc deficiency are 1) decrease in stem length, 2) reduced fruit bud formation, 3) mottled leaves, and 4) twig dieback.  Manganese is also an activator for growth enzymes, and it assists iron in chlorophyll formation. Often high levels of manganese may induce iron deficiency. Symptoms of manganese deficiency are 1) pale green leaves, 2) development of gray or brown or white specks or streaks.  Molybdenum is required in order to utilize nitrogen, because it enables plants to transform nitrates into amino acids. Symptoms of molybdenum deficiency include 1) stunted growth and lack of vigor; this is similar to nitrogen deficiency because molybdenum is so essential for the utilization of nitrogen, and 2) marginal scorching and cupping or rolling of leaves. | | | | |
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