Strawberry Nutrition: The ABCs of NP&K

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The strawberry plant is an herbaceous perennial. In New England, the plants typically exhibit leaf growth early in the spring, followed by flower bud emergence. The plants bloom and then fruit during the late spring early summer. Following a brief "rest" period after fruiting, the plants typically enter a phase of vegetative growth in the summer, including leaves and runners. As the daylength gets shorter and the temperature gets cooler during the late summer and fall, the plants start to produce fewer runners and more branch crowns, and develop fruit buds. The plants concentrate nutrients and carbohydrates in the crowns during the fall as the leaves senesce and the plants go dormant for the winter. As the growth of the strawberry plant changes during a season, so too do its nutrient demands. A strawberry grower should be aware of the changing needs of the plants and develop a fertilizer program that can meet those needs at the optimum time and in the optimum amounts. This will both promote excellent plant growth and utilize fertilizers as effectively and efficiently as possible.

A nutrient program begins with the soil. Careful attention to soil type, preparation and stewardship will encourage good plant growth and reduce stress. Regular testing of the soil to monitor its nutrient status and overall health is critical to maintaining good plant performance in the long term. Soils consist of several components, including minerals, organic matter, water and air. The type and amount of different minerals varies from one soil type to another. The solubility of these minerals and their availability to plants will also vary according to concentration, pH, temperature and other factors. Soil types that consist of mostly fine particles, such as silts and clays, hold more minerals than soils with larger particles, such as sand.

Organic matter is one of the most important components of any agricultural soil. Organic matter is basically decayed vegetable matter, including plant residues and manures, which are broken down by various soil organisms, primarily microbes. Organic matter is an important source of plant nutrients, including two of the three major nutrients: nitrogen (N), phosphorus (P) as well as minor nutrients, such as sulfur, and several micronutrients. Organic matter particles in the soil typically have a negative charge on their surface, which allows them to hold positively charged ions such as calcium, magnesium and iron. These ions can then be exchanged when they contact plant roots. Organic matter also plays an important role in binding the soil into friable clumps or colloids that make the soil more friable and allow air and water to move easily through. A good agriculture soil should contain a minimum of 2% organic matter. Levels of 6% or higher will provide optimal conditions for nutrient holding and exchange.

Water is another critical component of the soil. Water moves nutrients into and though the soil, and into the plants. Water also helps move minerals within the plant, and plays an important role in chemical reactions both in the soil and within the plant cells. Soils with finer particles (especially clay) can hold more water than soils with larger particles, but may drain poorly, and are difficult to get water into once they become dry.

A productive soil must also have plenty of air space. Plant roots need oxygen to survive and carry out their function of nutrient absorption. Air also provides a source of carbon and other ions the plant needs to build more complex compounds. Soils with large particle sizes tend to have greater pore space and thus more air. However, such soils also tend to have less water holding capacity and therefore are more susceptible to drought.

The three nutrients needed in the highest amounts by plants include nitrogen (N), phosphorus (P), and potassium (K). Typical granular fertilizer blends contain all three of these nutrients in various ratios and concentrations listed in the order of N, P and K. For example, a 10-10-10 fertilizer contains 10% nitrogen, 10% phosphorus and 10% potassium, respectively. Nitrogen is the most commonly applied nutrient because it is needed in relatively high amounts by plants, but most soils do not hold it in large available reserves. It is very soluble, so that any that is not soon taken up by the plants may quickly leach out of the soil.

The nitrogen available to plants in the soil occurs in two forms: the nitrate form (NO_3^-) and the ammonium form (NH_4^+). Nitrate is the preferred form for uptake by the plant. It is readily available for use and simple for the plant to metabolize. However, from a fertilizer perspective, it is more expensive than the ammonium form and more prone to leaching. Typical nitrogen fertilizers used on strawberries include urea (46% N), ammonium nitrate (34% N) and calcium nitrate (15% N). Organic growers often supply nitrogen by "front loading" or incorporating slowly available sources such as compost or green manures, which tend to have relatively low concentrations (2-3%). Other sources of nitrogen, both higher in concentration and more readily available to the plants, may also be used by organic growers, such as fish emulsion, dried blood or various dried plants meals (3-12% N), but these tend to be very expensive. The use of animal manures that have not been composted is not recommended. Although these may contain higher concentrations of nitrogen at a relatively low price, the risk of microbial contamination by organisms such as salmonella and E. coli is too great for fresh produce. No fresh manure should be applied to the soil within 120 days of harvest.

Nitrogen is an essential component in the synthesis of amino acids and proteins in the plant. As a fertilizer, it stimulates vegetative growth, such as leaves, petioles and shoots. Heavy applications are not recommended in the springtime because excess vegetative growth at this time will result in dense leaf canopy that will cover developing fruit, keeping it in a dark, cool wet micro-climate, and encouraging the development fruit rot such as gray mold. In a matted row system, the majority of nitrogen fertilizer should be applied during the summer months, following harvest when new leaf and shoot (runner) growth is needed to re-establish good planting vigor for next year's crop.

During the planting year (assuming the general fertility and condition of the soil is good), a strawberry planting should receive 20 to 40 pounds of actual nitrogen per acre incorporated into the soil prior to planting. Another 30 pounds should be applied in late June to early July, and a final 20 pounds can be applied in late August to early September. Each of these applications corresponds to periods of growth in the plants. Calcium nitrate (CaNo3, 15% N) is the recommended source of nitrogen in new plantings because it is readily available, not volatile, and also provides calcium. For established beds, only 10-20 pounds of actual nitrogen, if any, should be applied in the spring. As part of the renovation process following harvest, 50 to 70

pounds of nitrogen per acre should be applied to the planting, followed by 20 to 30 pounds in late August to early September. If nitrogen is being applied through an irrigation system, typical in plasticulture systems, pre-plant nutrients should be incorporated into the soil as recommended. In the planting year, three to four pounds of actual nitrogen per acre should be applied through the irrigation system per week from mid-May through early September. In the fruiting years, apply approximately 10 pounds of nitrogen per acre per week from mid July through late August.

Phosphorus is important in order for the plants to store energy, and plays a role in fruit development. It is often present in adequate amounts for good strawberry growth, but much of it is not readily available to the plants because it gets tied up in both the mineral and organic fractions of the soil. As a result, it does not tend to move through the soil or leach very easily. As a fertilizer, it becomes available to the plants slowly, and should be worked into the soil prior to planting to improve its uptake. Strawberries don't have a very high phosphorus demand, and deficiencies are relatively rare in New England. Availability is reduced if the soil pH is too low, or other nutrients, such as calcium are out of balance. Soil tests should read 20 to 30 ppm for optimal phosphorus uptake.

Although potassium, the third major nutrient, is needed in relatively high amounts by strawberries, deficiencies are fairly rare in New England. Soils often have sufficient potassium reserves, with 120 to 180 ppm being optimum the optimum range. Potassium is an important component of strawberry fruit and helps the plants regulate water movement and enzymatic reactions. Like phosphorus, it is slowly available and should be worked into the soil prior to planting to improve its uptake. Potassium may compete with magnesium for uptake by the roots and must therefore be kept in an appropriate ratio (4:1, K: Mg) in the soil to prevent one of these nutrients from overriding the other and creating a deficiency. Most soil tests calculate a "Base Saturation" to measure the balance of potassium, calcium and magnesium.

Calcium (Ca) is the first of what are known as the "minor" nutrients needed by the plant. Levels of calcium are usually adequate in the soil if the pH is in the appropriate range (6.0-6.2). Soils with a low pH may become calcium deficient. Ground limestone applied to the soil prior to planting is the most common source of calcium, with soil test levels of 1000 to 1500 ppm being optimal. Calcium is essential for building cell walls and membranes in the plant. It is not very mobile in the soil, or in the plant tissue. It should be worked into the soil to improve uptake. Cool soil temperatures and dry, droughty conditions will greatly limit the plants ability to take up calcium and may therefore induce a calcium deficiency even though adequate amounts are present in the soil. Calcium deficiencies are not uncommon in New England, especially in the spring. However, they can usually be attributed to cold soils, dry soils or low pH.

Magnesium (Mg) content of soils in New England varies greatly. Soil test levels of 120-180 ppm should provide optimal growth for strawberries. Availability of magnesium is reduced under low soil pH. Deficiencies in strawberry plants are not uncommon, but can be easily remedied. The most common source of magnesium is dolomitic or "high-mag" lime, which contains a significant percentage of magnesium, in addition to calcium. Epsom salts, also known as magnesium sulfate ($MgSO_4$) is another way to add magnesium to the soil, and may also be applied to plants as a foliar spray. Potassium can compete with magnesium for root uptake, and

should therefore be kept in an appropriate balance (4:1, K: Mg) to prevent one from causing a deficiency of the other.

In addition to the major and minor nutrients needed by the plants, some elements, while still required for good growth, are needed in only very small amounts. These are known as micro-nutrients. The most important micro-nutrients in terms of strawberries grown in New England include boron (B) and zinc (Zn). Others include iron, manganese, copper and molybdenum. Boron is essential for good root growth and pollination of the flowers. It is easily leached from the soil and is often deficient in New England. Although boron is often recommended as a nutrient supplement for strawberries, excessive levels can be toxic to the plants, so care must be taken to make sure that the plant has enough, but never too much. No more than one pound of actual boron per acre should be applied to a field in any year. Boron is often added to fertilizer blends of the major nutrients or applied in a foliar spray, such as Solubor (20% B)

Zinc, although needed in very small amounts by strawberry plants, is often deficient in New England soils, yet is very important in biochemical processes and fruit development. Zinc in the soil is more available to plants under low pH conditions. Heavy applications of lime and/or phosphorus can reduce the availability of zinc to the plants. The optimal level of zinc in leaf tissue is 35 ppm. It is typically applied as part of a fertilizer blend to the soil, or applied as a foliar spray, to help achieve uniform distribution of a small amount of material over a relatively large area.

Soil pH has a strong influence on nutrient availability, and should be regularly monitored and corrected as needed through applications of ground limestone or some other liming agent. A low pH or acid soil will have reduced availability of nitrogen, phosphorus, potassium, magnesium and molybdenum, while a high pH or alkaline soil will have reduced availability of zinc, boron, iron, manganese, and copper. To maintain nutrients at their optimum availability and balance in the soil, the pH should be maintained at 6.0 to 6.2, i.e., slightly acidic (7.0 being neutral). Limestone takes some time to go into solution and react with the soil to change the pH, so applications needed to significantly correct a very acid soil should be made well in advance of planting, and may be split over two to three years. The soil should be tested to monitor the pH every two to three years to assure that only small corrections will be needed at any one time. In general, soils in New England will tend to acidify over time, due to acid rain and fertilizer applications. For most soils, a “maintenance” application of two tons of ground limestone per acre per year, will keep the soil at a relatively stable pH.

For more information on strawberry nutrition, consult the Strawberry Production Guide, available from NRAES at nraes.org (607) 254-7654 or your state university Cooperative Extension.