Fertilizing Grapes

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Fertilizing grapes can increase annual yields, enhance grape and wine quality, and improve soil's biological and chemical properties. As a deep-rooted, perennial crop, grapes remove a significant amount of nutrients from the soil and depend on adequate nutrient management to account for what is lost. Factors influencing nutrient removal are type of rootstock, variety and origin, yield, age of the planting, weather, soil type, bio-chemical characteristics and interactions. A wide range of annual nutrient removal amounts have been cited throughout the years in literature (Table 1).

MACRONUTRIENT REMOVAL						
Researcher	**N**		**P2O5**		**K2O**	
	kg/ha	lb./a	kg/ha	lb./a	kg/ha	lb./a
Buzin	75.52	67.4	26.78	23.9	76.27	68.1
Mozer	80	71.4	100	89.25	250	223.1
Müntz	37	32.8	11	9.8	40	35.7
Ravaz	15	13.4	50	44.63	100	89.25

Table 1. Macronutrient Removal.
Source: *L. Avramov: Prakticno Vinogradarstvo, Nolit-1974*

Taking the Soil Sample

A combination of soil testing and tissue analysis is the best way to understand the nutrient levels and determine the fertilizer needs.

Soil samples are collected in fall or spring. Adequate soil sampling requires that the sample be representative of the entire area, with a pint of soil representing an entire field. A higher number of subsamples taken across the area will provide more accurate results. Take random samples using a soil-probe (available at a local WVU Extension Service office) to the depth of 8 inches, and if possible, even deeper to 12 to 18 inches. Place the pulled cores into a bucket and mix the collected soil cores well. Take a pint or slightly more of well-mixed soil, place it in a gallon-sized plastic bag and take it to the local WVU Extension Service office where they can help with filling out the soil testing request form and further processing.

Soil Analysis

Soil tests provide necessary information about nutrient presence and availability, taking in consideration pH and cation exchange capacity. The emphasis is on soluble and mobile forms of individual nutrients, which, to some extent, determines their availability to the plants. Mobility implies to all forms and

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amounts of nutrients passing into any extract: water, salt solution, dilute strong mineral or weak organic acids, alkaline solutions or any other solutions.

There are 18 essential elements derived from the soil or air that are necessary for plant growth and proper development. They are classified in two major groups – macronutrients and micronutrients.

Macronutrients are used in large quantities by the plant and can be subdivided into three categories: primary nutrients, such as nitrogen (N), phosphorus (P) and potassium (K); secondary nutrients, such as magnesium (Mg), calcium (Ca) and sulfur (S); and structural nutrients, such as carbon (C), hydrogen (H) and oxygen (O).

Micronutrients consist of iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu), cobalt (Co), chlorine (Cl), nickel (Ni) and molybdenum (Mo).

Nutrients may be mobile or immobile in the soil, as well as in the plant, influencing the redistribution of nutrients through the plant and resulting in deficiency or surplus of toxic symptoms. Another important fact is that demands for nutrients change based on the life cycle and life stage of the plant. There is high demand for nutrients during intense vegetative growth, such as every spring; the demand is then tapered down during reproductive development.

Soil pH is one of the most important limiting factors for mineral availability. The optimum pH values for grapes range from 5.5 to 6.5. Generally, American grapes (Vitis lambrusca) prefer a lower pH of 5.5 to 6, while European grapes (Vitis vinifera) and hybrids prefer a higher pH of 6.5.

Cation exchange capacity (CEC) is the ability of a soil to release, absorb and retain positively charged elements like potassium, calcium, sodium, magnesium, etc. These positively charged cations (e.g., K++, Ca++, H+, Mg ++) are exchanged on the surface of the soil particles, binding to them since the soil is negatively charged. With soil acidity rising, these main cations are replaced with hydrogen, aluminum and manganese.

For example, when potassium binds to the soil particle, it pushes out calcium, releasing it into the water solution within the soil, making it available for root uptake.

Most of the plant's calcium, magnesium and potassium comes from the exchange sites. Generally, heavier soils with higher organic matter content have more cation exchange sites and higher CEC values. Sandy soils typically have CEC values from 1 to 5; silt soils, 5 to 20; clay, 20 to 30; and organic soils, higher than 30. Soil fertility is defined by the CEC values.

Tissue Analysis

Following nutrient levels within grape vines is best achieved through annual tissue analysis once the vines start producing, usually from the third year until the yields stabilize. Standard practice is to do a petiole analysis by collecting samples close to maturation, once the grape berries start to change color, a stage known as veraison. Usually, about 40 to 60 petioles, with a minimum of two petioles per plant, are adequate for tissue analysis. Research has shown that the petioles are not a very strong indicator of nitrogen and micronutrient levels.

More accurate readings are provided by leaf analysis. About 50 mature leaves from the middle of the current season's shoot are collected in June. Regardless of which tissue sample is collected, it needs to be triple-rinsed to avoid any contamination by spray residue and dust, air dried and sent to the lab for analysis.

STANDARDS FOR GRAPE PETIOLE ANALYSIS			
Element	**Low**	**Normal**	**High**
N (%)	<0.5	0.8 – 1.3	>2
P (%)	<0.1	0.16 – 0.3	>0.5
K (%)	<1	1.5 – 2.5	>4
Ca (%)	<0.8	1 – 1.8	>3
Mg (%)	<0.2	0.25 – 0.45	>0.8
Mn (ppm)	<25	30 – 150	>200
B (ppm)	<20	30 – 50	>80
Cu (ppm)	<3	5 – 15	>20
Fe (ppm)	<25	30 – 50	>200
Zn	<20	30 – 50	>80

Table 2. Standards for Grape Petiole Analysis.

Source: *Compiled by M. Danilovich (2004) from Yagodin (1984), Stiles & Reid (1991) and Bennet (1994)*

Macronutrients

Nitrogen (N)

Among primary nutrients, nitrogen is required in relatively large quantities for ensuring good vigor and yield. It is a building block of chlorophyll and plays a major role in protein synthesis. In vineyards that exhibit low levels of nitrogen, leaves develop a pale green to yellow color. Younger leaves are not immediately affected since the nitrogen moves from the older leaves to the points of new growth. Symptoms first appear on the older leaves. Generally, the vegetative growth is poor, with leaves that are stunted, weak flower buds, poor fruit set and reduced yields.

On the other end of the spectrum, too much nitrogen can cause excess growth, delayed ripening, increased susceptibility to disease at harvest time, increased susceptibility to winter injury and poor-quality fruit. High levels of nitrogen can induce the appearance of deficiency symptoms of phosphorous, boron and copper.

Due to high leaching potential, nitrogen is best applied in split applications; the first should be around bud break, and the second around bloom or within two weeks immediately following bloom, which is around the fruit-set stage. Recommended rates range from 40 to 100 pounds per acre of nitrogen. The amount depends on the tissue analysis. If the nitrogen is deficient, 80 to 100 pounds per acre needs to be applied; if the results indicate normal levels of nitrogen, no more than 60 pounds per acre is needed.

Phosphorus (P)

Just like nitrogen, phosphorus is essential in metabolic processes. It is known as an "energy" element as it is a building block of adenosine triphosphate (ATP), which regulates energy transfer in metabolic processes. It is involved in photosynthesis; sugar, oil and starch formation; encourages root development; influences blooming and influences stress response. Generally, soils have sufficient levels of phosphorus unless there is low pH that can restrict availability. In the case of a deficiency, fertilizer blends with phosphorus, or a superphosphate fertilizer could be applied to correct the problem, with amounts based on soil and tissue analysis.

Potassium (K)

Potassium is in high demand. It is involved in protein synthesis and photosynthesis. It influences color development, the maturation process and insect and disease tolerance due to the role it plays in cell wall structure.

Potassium deficiency symptoms start appearing in mid-summer. Symptoms start at the middle of the shoot, then radiate toward the shoot base. Leaves take on a bronze appearance and exhibit typical margins that appear burned, much like a leafhopper burn (Figure 1). In more severe cases, dark necrotic spots may appear throughout the leaf. Problems with potassium deficiency are more common on heavy soils with a pH of 7 or higher because potassium becomes chemically bound and unavailable for absorption.

Available fertilizers are potassium sulfate with 50 percent of K2O, potassium nitrate with 44 percent of K2O and potassium chloride, or muriate of potash, with 60 percent of K2O.

A longer lasting effect is obtained by soil applications, though it is possible to do foliar sprays. Foliar applications have a quicker response time and are suitable for a short-term correction, but are not intended to replace fertilizing the soil. Foliar sprays are mixed at a rate of 6 to 10 pounds of potassium nitrate (KNO3) or potassium sulfate (KSO4) per 100 gallons of water and applied at a rate of 200 gallons per acre for mature vineyards.

Figure 1. Potassium deficiency in Concord grape.

Photo credit: Mark Longstroth, Michigan State University

Secondary Nutrients

Magnesium (Mg)

Magnesium is a building block of chlorophyll, helps in photosynthesis and has a very important role in enzyme activation. Lack of magnesium leads to reduced phosphorus metabolic activity through reduced photosynthesis and carbohydrate, nucleic acid and protein synthesis. Magnesium deficiency is usually a problem in acidic soils and where there is an antagonistic effect between available nutrients in the soil. The antagonism refers to the competition between nutrients for uptake by plants. Potassium access will restrict magnesium uptake and calcium access, leading to magnesium deficiency and related abnormalities.

Deficiency symptoms first appear on older leaves with marginal and interveinal yellowing (chlorosis), manifested as yellowing or pale green areas between the veins of older leaves while veins remain green (Figure 2). Those pale green or yellow areas often turn brown and die. Leaves can turn reddish to purple as a result of the reduced phosphorus metabolic activity. Younger leaves and even terminal leaves become chlorotic in severe cases of magnesium deficiency.

If the pH is low and liming is recommended, dolomitic lime is preferred due to its magnesium component. Follow the application with a magnesium sulfate spray, and ground application is needed. Foliar spray rate is 10 to 16 pounds of magnesium sulfate (Epsom salt) per 100 gallons of water at the rate of 200 to 300 gallons per acre. For the small vineyards or the home garden variety, use 1/3 ounce per pint of water.

Figure 2. Magnesium deficiency expressed as interveinal yellowing and reddish-purple margins.

Photo Credit: Mark Longstroth, Michigan State University

Calcium (Ca)

Calcium is probably the most important among the secondary nutrients. It is an essential building block of cell walls that provides firmness, thereby increasing shelf life for table grapes and indirectly influencing disease and insect susceptibility. Generally, calcium is present in soil in sufficient levels. In rare occasions when calcium needs to be added, it can be applied through lime or by foliar sprays. A foliar application of calcium nitrate (Ca(NO3)2) that is 19 percent calcium and 15 percent nitrogen, and to a lesser extent, calcium chloride (CaCl2) with 36 percent calcium due to its high corrosive nature is recommended.

Sulfur (S)

Sulfur is important for amino acids and protein synthesis. It helps in forming chlorophyll, promotes root growth and helps seeds form. It also influences cold resistance. Sulfur is rarely deficient since it is added through acid rain, some fertilizers (sulfur-coated urea) and disease-control sprays.

Micronutrients

Boron (B)

Boron is essential for plant growth, as it is a building block in fruit cell walls, regulates transfer of sugars and assimilates from the leaves to the fruit. It plays very important role in fruit set. It facilitates pollen germination and pollen tube growth and penetration. A lack of boron leads to incomplete fertilization, poor seed development, late abortiveness and massive premature fruit drop (Figure 3). Borax or borate could be either sprayed or applied to the soil surface. Spray in fall before leaf senescence or in spring a couple of weeks before bloom, so boron will be at the base of the flowers in time for pollination and fertilization.

Iron (Fe)

Iron is essential in energy transfer during transpiration and it regulates chlorophyll formation. Deficiency manifests itself in the form of chlorosis with distinct and prominent green areas along veins (Figure 4). Terminal growth is stunted in severe cases. Correct the problem by applying chelated iron.

Manganese (Mn)

Manganese is part of chloroplast and plays an important role in photosynthesis. Deficiency symptoms appear as intraveinal chlorosis with dark green areas along the veins (Figure 5). It typically appears in plants in sandy soils with higher pH values. Manganese toxicity is rare in grapes, but if it does occur, it

Figure 3. A boron-deficient Thompson Seedless cluster in the trial vineyard shows reduced fruit-set, the presence of numerous pumpkin-shaped "shot berries" and necrosis of some branching. Fewer than 10 percent of the berries are normal size and shape.

Photo credit: Christensen et al. (2006)

Figure 4. Iron deficiency in grape.

Photo credit: M. Danilovich, WVU

Figure 5. Manganese deficiency symptoms.

Photo credit: http://www.omafra.gov.on.ca/IPM/images/grapes/ocw/mn-ocw-fe.jpg?rand=465446044 appears as black spots on leaves and spots and pitting on shoots and bunch stems (measles).

Zinc (Zn)

Zinc is a component in many enzymes that regulates the electron transfer system, protein synthesis and degradation, and it is part of growth hormone (auxin) and plays major role in regulating plant growth. Symptoms of deficiency first appear on the older leaves as interveinal mottling or yellowing between the veins (interveinal chlorosis). In cases of severe deficiency, typical symptoms include abnormal growth. Since zinc is not mobile in the plant, the symptoms occur in new growth. The most recognizable symptoms are short internodes or "rosetting" and small size leaves known as "little leaf" (Figure 6).

Leaves drop off from the shoot, leaving little tufts of small, deformed leaves on the tip of the shoot. As a result, there is reduced flower bud formation and buds are small and weak, producing fruit that is small, misshapen and of poor quality. It shows an uneven ripening pattern and fruit has a tendency to drop off prematurely.

Zinc deficiency may be emphasized due to the antagonistic effect where there is an excess of lime. Soils with high phosphorus levels or where high amounts of phosphorus fertilizer are applied can lead to zinc deficiency. Phosphorus reacts with zinc, creating a chemical bond and making it unavailable to the roots.

Figure 6. Zinc deficiency symptoms: chlorosis and stunt shoot.

Photo credit: http://www.omafra.gov.on.ca/IPM/images/grapes/plant-nutrition/zinc/zinc2_zoom.jpg?rand=926238950

Copper (Cu)

Copper is part of enzymes and many metabolic processes. Copper deficiency is very rare and symptoms indicate low shoot and vine vigor, reduced yields, poor hardening of the shoots and often, rough bark appearance. Due to intense use of copper fungicides for disease control, copper toxicity may develop. As a result of the antagonistic effect on phosphorous, iron and zinc, high levels of copper lead to very low levels of these three elements in plant tissue.

Molybdenum (Mo)

Molybdenum is involved in the synthesis of pigments and chlorophyll. It plays a major role in nitrogen metabolism. Research in Australia has shown that low levels of molybdenum lead to toxic levels of nitrates, with symptoms indicating shoot tip die back, low productivity and low vigor. Merlot seems to be particularly sensitive and this phenomenon is known as "Merlot disorder." Molybdenum applications correct the problem.

Best Timing for Fertilizer Application

Generally, there are three periods during the season when fertilizer applications are particularly beneficial. The first is in spring, at the bud break, when there is a rapid tissue expansion and growth quickly using up stored carbohydrate reserves. Fertilizer application at that time will ensure good growth at the beginning of the season. A second application should follow within three weeks after the petal fall/fruit set to provide energy for cell division within the fruitlets, ensuring larger berries and good crop. The third recommended timing for fertilizer application is after the harvest to help vines produce and store carbohydrates for the winter and early growth in the next season.

References

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For more information

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