STRAWBERRY FERTILITY AND NUTRIENT MANAGEMENT

NCDA&CS Agronomic Division
Plant/Waste/Solution/Media Section
originally prepared by Shaun Casteel, 2004

Revised November 2011

INTRODUCTION

Optimal strawberry production requires a favorable root environment and the availability of essential nutrients. Soil pH is a key factor in maintaining a favorable root environment. It not only affects root growth but influences availability of many nutrients.

Some essential nutrients required for plant growth include the major elements nitrogen (N), phosphorus (P) and potassium (K); the secondary elements calcium (Ca), magnesium (Mg) and sulfur (S); and the micronutrients iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B) and molybdenum (Mo).

Major elements are required in greatest quantity, followed by secondary elements, then micronutrients. Nitrogen, phosphorus and potassium are especially important for optimum yield and quality. Secondary elements play significant roles in photosynthesis, cell wall development and protein production. Micronutrients are required in very low quantities but are essential for normal growth and development. They generally function as catalysts for chemical reactions in the plant. Excess quantities of micronutrients can be toxic.

FERTILITY

A good nutrient management strategy addresses as many of the nutritional requirements as possible in preplant applications. Based on soil-test recommendations, soil pH and calcium saturation should be adjusted three to four months ahead of bed forming and fumigation. A soil pH of 6.0–6.2 is considered ideal for mineral soil, 5.5 for mineral-organic soil and 5.0 for organic soil. In general, applications of phosphate (P_2O_5), potash (K_2O), magnesium and micronutrients should be based on soil-test recommendations and made at bed forming. Nitrogen and potash should be applied in quantities adequate to support fall growth. If too much nitrogen and potash are applied, plants are likely to produce excess vegetative growth and set fewer fruit. Following NCDA&CS soil-test guidelines, that is applying nutrients according to soil-test recommendations, is a good way to optimize cost-benefit ratio and protect the environment from the effects of nutrient leaching. If a good job of fall fertilization is done, the nutritional needs of the crop should be met until vegetative growth begins in the spring.

Nitrogen

Research by NCDA&CS and NCSU reveals that the optimal N rate for production of 'Chandler' strawberry is approximately 120 lb/acre on sandy soils under plasticulture (Miner et al., 1997). Approximately one half of the N should be applied in the fall and the remainder applied through drip irrigation in the spring. Apparent benefits include reduced vegetative growth and firmer fruit without sacrifice in market yield. Strategically timed, spring N applications during the vegetative and fruiting period have been shown to increase yield in California (Ulrich et. al, 1980). Specific spring N recommendations are based on leaf and petiole tissue analysis (see ***Petiole Nitrate Nitrogen Monitoring***). Total spring N rates will vary

depending on the soil type. Deep sandy soil will require the highest rates followed by medium-textured soil and the lower rate on heavy textured soil.

Initiaton of Spring N

According to Campbell and Miner (1998), the timing of N through the irrigation tape in the spring is somewhat flexible. But the strawberry crop's need for N increases rapidly as spring growth begins. Therefore, it is advisable not to wait too long before initiating N application. The general N recommendation is 0.75 lb/acre/day, which represents the mean of 0.5 and 1.0 lb/acre/day, the rates that were suitable in the research years 1994 and 1995.

Frequency of Drip N

Frequency of N applications through the irrigation tape varies with cultural practices of respective growers. Time and crop diversification can often influence the interval between drip-N applications. Campbell and Miner (1998) found no difference in total and market yield based on 1-, 2-, 3- or 4-week intervals between N injections. Total spring N was the same regardless of intervals. This work indicates that spoon-feeding is not required, and drip N can be spring applied in three or four applications provided growers do not overirrigate and leach N from the root zone. For greatly diversified growers, this N-application system could reduce workload. However, the week-to-week nutritional status can vary, making it more difficult to evaluate a fertility program. Other nutrients such as potassium, sulfur and boron may require adjustment throughout the season. The additional adjustments could equal the workload required for weekly or biweekly routine N applications. Additionally, corrective action seems to be easier with a weekly or a biweekly schedule. The take-away point is to apply N on a schedule that fits the grower's needs without jeopardizing yield and quality.

Phosphorus

Tissue tests indicate that P levels in strawberry plants can be sufficient during most of the growing season yet still drop to low levels during harvest. This drop has occurred in fields with adequate to high soil-P indices. Miner and Campbell (1997) evaluated fall-applied P_2O_5 (0, 60 lb/acre) and spring-, drip-applied P_2O_5 (multiple rates and timings) on a loamy sand with a high soil-P index. Results indicated significant increases in total, cull and market yield with the 60-lb/acre, fall-applied rate versus the check. Spring-applied P_2O_5 did increase leaf-P content in some treatments but did not increase any yield parameters. The yield response from fall-applied P_2O_5 may be due to early flower initiation prior to cooler temperatures. As soil cools, P becomes less available to the plant. In general, a fall P_2O_5 application of 30–60 lb/acre should be incorporated even on high-P-index soil.

Potassium

Miner et al. (1997) found no improvements in yield and fruit quality from a spring drip application of K. In this study, the NCDA&CS recommendation for fall-applied K_2O (120 lb/acre) was sufficient. Additional K_2O applied through the drip (up to 200 lb/acre) produced no apparent benefit. A good rule of thumb is to adhere to the NCDA&CS soil test recommendations for K and to make adjustments as needed according to tissue analysis.

Manure Applications

Farm manure applications on strawberry fields can improve tilth, enhance water-holding capacity and provide all essential nutrients. However, overapplication can lead to soft fruit.

Growers who plan to use manure as fertilizer should have samples analyzed by the NCDA&CS Plant/Waste/Solution/Media laboratory prior to application. Ideally, the farm manure should be applied at rates needed to supply N unless concentrations of other nutrients limit that application rate. Where manures are used in strawberry production, growers should proceed with caution in the spring. Leaf and petiole samples become critical parts of management. Routine samples should be taken to identify the need for additional N in the spring.

Common Fertility Concerns

Soil management concerns include soil pH, calcium and magnesium levels, and soluble salts. Low pH is the most significant and predominant problem identified on soil samples submitted from strawberry fields in North Carolina. This is unfortunate since the problem cannot be corrected in a timely manner if the crop has already been planted. Low calcium and magnesium usually accompany low pH. In such cases, dolomitic lime is an excellent choice to raise pH and provide calcium and magnesium. Magnesium can also be limiting on sandy soils that have a very limited nutrient-holding capacity even though soil pH is ideal. Soluble salts are a problem where fertilizer application has been excessive and/or moisture inadequate. In the past several growing seasons, low sulfur indices have been a trend.

Strawberry tissue samples identify low nitrogen, sulfur and/or magnesium most often. Calcium, potassium and boron are also limiting in a number of samples. Low N levels are identified via petiole-nitrate analysis. Fortunately, in the plasticulture system, it is easy to inject additional N as recommended by a plant tissue report.

Tissue analysis often indicates that N levels are high in the leaf tissue relative to S levels during the bloom/fruit period. This imbalance between nitrogen and sulfur (reported as a high N:S ratio) can be corrected with an application of sulfur. The best management approach is to supply only as much N as required but if sulfur is needed during the spring, magnesium sulfate (Epsom salts) or potassium sulfate are good sources for drip injection.

NUTRIENT MANAGEMENT TOOLS

Strawberry growers have a number of tools at their disposal to help manage crop nutrition and diagnose problems. Observation and experience are very important in conjunction with soil, plant and solution analyses. These analyses provide growers with initial soil nutrient information, a snapshot of plant nutritional status and information on any limitations of irrigation water. These nutritional data combined with observation and experience help growers optimize yield, quality and length of fruiting season. Decisions based on such data are also more likely to enhance profit and protect the environment.

A soil test measures residual acidity and nutrient availability (Ca, Mg, P, K, Mn, Zn, Cu). It predicts lime and fertilizer rates required for optimum crop performance. A soil test is predictive and is best suited for elements that are not mobile with soil water.

Plant, or tissue, analysis is the chemical processes that detect nutritional status at a given point in the life cycle of a crop. This analysis complements soil testing and is particularly helpful in evaluating the need fornutrients such as nitrogen, potassium, sulfur and boron. These nutrients can be a concern especially for crops growing in sandy soils where leaching due to excessive rainfall is common.

Additionally, plant analysis measures nitrate-N (NO_3-N)concentration within petioles. This analysis is a direct reflection of soil-N availability on the day of collection. This information makes it possible to fine-tune N application, to maximize yield and quality and to extend the fruiting season.

Tissue Sampling

The key to success in a nutrient monitoring program is to sample the correct tissue in a timely manner. Research studies indicate that the most recent mature leaf (trifoliate) is the best indicator of the elements most essential for plant growth: P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, and B. Sufficiency ranges for nutrients in the most recent mature trifoliate leaf (MRML) are as follows: 3.0–4.0% N, 0.2–0.4% P, 1.1–2.5% K, 0.5–1.5% Ca, 0.25–0.45% Mg, 0.15–0.40% S, 50–300 ppm Fe, 30–300 ppm Mn, 15–60 ppm Zn, 3–15 ppm Cu, and 25–50 ppm B (Campbell and Miner, 2000). The petiole from this same trifoliate leaf is the best indicator of N status (nitrate N).

It is critical that each sample is properly described on the *Plant Sample Information* form (see supplement section). Designation of growth stage and week is very important, especially during the bloom and fruit growth stages (see Spotlight on Strawberry Tissue Analysis and Spring Nitrogen Recommendations in The Strawberry Grower, 2011). The week of bloom/fruit corresponds to the NO_3-N sufficiency range. The N rate recommended is based whether NO_3-N is below, within or above the sufficiency range. As spring growth progresses, petiole-nitrate-N levels begin to decrease. During the bloom/fruit period, proper information to be provided includes growth stage (B, bloom), week (week number for this growth stage), plant part (M, most recent mature leaf) and plant position (U, upper). For further assistance, please contact your county Cooperative Extension office or the NCDA&CS regional agronomist in your area (see *NCDA&CS Agronomic Division Field Services* in the supplement section.

Time of Sampling

Both leaf and soil samples should be taken in the fall if questions arise concerning plant establishment, vegetative growth and crown development. The best procedure is to take leaf samples from good and bad plants for comparison. A soil core should be taken from the root zones of plants sampled in each of these respective areas.

Spring sampling for monitoring should begin about March 1st and continue at two-week intervals throughout the blooming/fruiting season. Earlier sampling may be necessary in southern and eastern regions. Monitoring nutritional status with 6–8 samples per cultivar from each field during the growing season and following the recommendations will assure that nutritional status is optimum at all times. A good sample database makes it possible to evaluate fertility practices relative to yield, weather and other production factors.

Best Indicator Tissue Sample

The most recent mature trifoliate leaf (MRML) and the associated petiole are the best indicators of nutritional status (Figure 1). The MRML is a fully expanded leaf. It is neither dull from age nor slick with a light-green sheen like an immature leaf (Figure 2). A good sample consists of 15–20 leaves and associated petioles (Figure 3). The petiole must be detached from the plant near the crown. Petioles should then be removed from the leaf (Figure 4) and placed in a small envelope within the leaf blade container (Figure 5). It is important that entire petioles be sent to the NCDA&CS Plant/Waste/Solution/Media laboratory for evaluation. Partial petioles are not reliable indicators of N status.

Petiole Nitrate Nitrogen Monitoring

Leaf and petiole samples can predict the need for corrective measures and adjustments to the feeding program. Until a problem is identified, growers should continue to apply N as planned

(preplant plus spring application). In most cases, 60 lb/acre applied preplant followed by spring applications totaling 60 lb/acre should be adequate. On heavy-textured soils, plants may require less N. Fertigation provides an excellent means not only for meeting N requirements of the crop but also for limiting excessive use of fertilizer.

In general, the nitrate-N concentration should never be below 500 ppm. Exceptions to this rule would be during early winter dormancy (December–January) and after fruiting (July). During plant establishment (fall), petiole-nitrate N should approach 1500–2000 ppm. During vegetative growth (early spring), nitrate N should increase to 3000–4000 ppm by early fruit picking then gradually decline to 500 ppm by the end of harvest. Nitrate N in excess of 10,000 ppm may depress yield and limit quality (i.e., fruit firmness). For a quick reference on the desired petiole-nitrate ranges for the period of bloom/fruit, please look at *Strawberry Tissue Analysis* in the supplement section.

Additional Information

For N.C. residents, NCDA&CS soil tests are free, strawberry plant tissue analysis costs $7.00 per sample, and waste and solution analyses cost $5.00 per sample (payment is due upon submission). Your county Cooperative Extension office should have packets and sample information forms in supply. NCDA&CS regional agronomists are located across North Carolina to provide assistance in proper sampling, report interpretation and recommendation of corrective action (see *NCDA&CS Agronomic Division Field Services* in the supplement section). You may also find other pertinent information at the NCDA&CS Agronomic Division homepage (www.ncagr.gov/agronomi/).

Links

Most recent Plant Sample Information form: http://ncagr.gov/agronomi/pdffiles/isplant.pdf

Understanding the Plant Analysis Report: http://ncagr.gov/agronomi/pdffiles/uplant.pdf

Strawberry Tissue analysis: http://ncagr.gov/agronomi/pdffiles/sberrypta.pdf

REFERENCES

Campbell, C.R., and G.S. Miner. 1998. Nutrient management for strawberry production. *In*: Strawberry plasticulture notebook: a guide to strawberry plasticulture production. N.C. Strawberry Association, Pittsboro.

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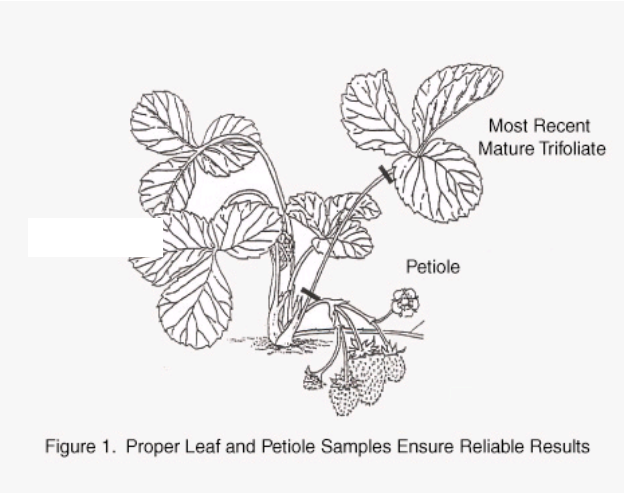


Figure 1. Proper Leaf and Petiole Samples Ensure Reliable Results

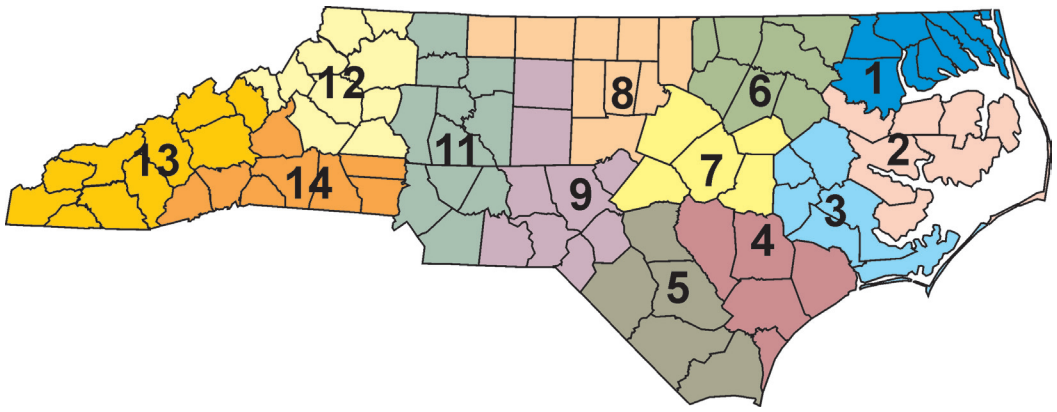
Figure 2. Most recent mature trifoliate leaf (MRML).

Figure 3. Representative sample (at least 20 leaves).

Figure 4. Detach petioles from leaf blades.

Figure 5. Proper sample bags and submission.

Agronomic Division Field Services Regions/Counties	Regional Agronomist Phone
Region 1: Bertie, Camden, Chowan, Currituck, Gates, Hertford, Pasquotank, Perquimans	**Wayne Nixon** (252) 335-4142
Region 2: Beaufort, Dare, Hyde, Martin, Pamlico, Tyrrell, Washington	Currently unassigned. Contact Kent Messick (919) 733-2655
Region 3: Craven, Carteret, Greene, Jones, Lenoir & Pitt	**Dianne Farrer, Ph.D.** (252) 830-1718
Region 4: Duplin, New Hanover, Onslow, Pender, Sampson	**Tim Hall** (910) 324-9924
Region 5: Bladen, Brunswick, Columbus, Cumberland, Robeson	**Rick Morris** (910) 866-5485
Region 6: Edgecombe, Franklin, Halifax, Nash, Northampton, Vance, Warren	**Kent Yarborough** (252) 340-1135
Region 7: Harnett, Johnston, Wake, Wayne, Wilson	**Don Nicholson** (919) 498-0504
Region 8: Alamance, Caswell, Chatham, Durham, Granville, Orange, Person, Rockingham, Stokes	**Robin Watson** (336) 570-6850
Region 9: Anson, Guilford, Hoke, Lee, Montgomery, Moore, Randolph, Richmond, Scotland	**David Dycus** (919) 776-9338
Region 10: no longer exists	
Region 11: Cabarrus, Davidson, Davie, Forsyth, Iredell, Mecklenberg, Rowan, Stanly, Surry, Union, Yadkin	**Ben Knox** (704) 278-9414
Region 12: Alexander, Alleghany, Ashe, Avery, Burke, Caldwell, Catawba, Mitchell, Watauga, Wilkes	Currently unassigned. Contact Kent Messick (919) 733-2655
Region 13: Buncombe, Cherokee, Clay, Graham, Haywood, Jackson, Macon, Madison, Swain, Yancey	**Bill Yarborough** (828) 456-3943
Region 14: Cleveland, Gaston, Henderson, Lincoln, McDowell, Polk, Rutherford, Transylvania	**Steve Dillon** (704) 276-1989



Strawberry Tissue Analysis

N.C. Dept. of Agriculture & Consumer Services Agronomic Division
Location: 4300 Reedy Creek Rd, Raleigh, NC 27607-6465
Mailing Address: 1040 Mail Service Center, Raleigh, NC 27699-1040
Phone: (919) 733-2655
Web Site: www.ncagr.gov/agronomi

February
2009

Plant Tissue Nutrient Sufficiency Ranges for Strawberry*

Nutrients	Sufficiency Range
N (%)	3–4
P (%)	0.2–0.4
K (%)	1.1–2.5
Ca (%)	0.5–1.5
Mg (%)	0.25–0.45
S (%)	0.15–0.4
Fe (ppm)	50–300
Mn (ppm)	30–300
Zn (ppm)	15–60
Cu (ppm)	3–15
B (ppm)	25–50

Petiole Nitrate Nitrogen for Bloom and Fruit

Week *	Low	High
1	600	1500
2–3	4000	6000
4	3500	6000
5–8	3000	5000
9	2000	4500
10	2000	4000
11	1500	3000
12	1000	2000

* Sampling generally begins the first week of March and continues for 12 weeks.

* Campbell CR, Miner GS. 2000. Strawberry, annual hill culture. In: Campbell CR, editor. Reference sufficiency ranges for plant analysis in the southern region of the United States. Raleigh (NC): NC Dept of Agriculture & Consumer Services. Southern Cooperative Series Bulletin 394. [www.ncagr.gov/agronomi/saaesd/sberry.htm]

Plant tissue analysis measures nutrient concentrations within growing plants. Testing of strawberry leaves and petioles provides information on whether or not nutrients are sufficient for optimum crop development. Not only does it identify and verify observed nutrient deficiencies and/or toxicities, but it can also identify nutrient shortages before symptoms appear.

Plant tissue samples can be predictive or diagnostic. Routine samples are predictive: that is, they identify nutrient levels within the crop and predict an appropriate approach to fertilization. Diagnostic samples are submitted to identify apparent nutrient problems.

Routine (predictive) analysis measures levels of nutrients present: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, manganese, copper, zinc, iron, boron and sodium. Results indicate whether plants are absorbing adequate amounts of the nutrients needed for optimum growth. Plant analysis reports give growers the information they need to evaluate the effectiveness of their current fertilization program.

Problem (diagnostic) analysis measures the same nutrients as routine analysis. However, the main goal of the analysis is to identify observed nutrient problems accurately. The best way to do this is to submit samples from "good" areas (normal-looking plants) and from "bad" areas (discolored, stunted or misshapen plants) and compare the results. Matching soil samples from the two areas can also provide useful information.

Plant tissue samples must be properly collected, carefully handled, and submitted to a recognized laboratory. Because nutrient concentrations throughout a plant vary, the correct plant part must be sampled, and it must be at the proper stage of growth. Improperly collected tissue samples can produce unreliable results and lead to incorrect interpretations. Plant nutrient concentrations determined by tissue analysis are compared with sufficiency ranges found in normal plants.

To collect and submit a strawberry tissue samples, follow these guidelines.

- Select the most recently mature, trifoliate leaves (MRMLs). Those leaves are full-sized and green and consist of one petiole or leaf stalk with three leaflets. MRMLs are usually located three to five leaves back from the growing point.
- Avoid collecting dull, older leaves or damaged tissue.
- Detach the petioles from the leaves as you collect them, but submit them together as one sample.
- Include leaves and petioles from 20 to 25 plants within a uniform area. For example, all of the plant material in a single sample should be the same variety, growing on the same soil type, planted at the same time and having the same management history. This is known as a representative sample.
- Fill out the NCDA&CS *Plant Sample Information* form, including fertilization history and environmental conditions. Provide the name of the strawberry variety being grown as well as its stage of growth at time of sampling. Stage of growth refers to week of bloom and can be coded B1 through B12 (first through 12th week of bloom). This determination can also be estimated relative to week of first harvest, which is typically B6. Accurate management recommendations depend on this information.

Form AD-4 (July 2011)

PLANT SAMPLE INFORMATION

SAMPLE TYPE
[circle designation(s) / instructions on back]

Predictive	Diagnostic
Research	Out of State

NCDA&CS Agronomic Division Plant/Waste/Solution/Media Section
Mailing Address: 1040 Mail Service Center, Raleigh NC 27699-1040
Physical Address (UPS/FedEx): 4300 Reedy Creek Road, Raleigh NC 27607
Phone: (919) 733-2655 Web Address: www.ncagr.gov/agronomi

FOR OFFICE USE ONLY
REPORT #
DATE REC'D
INITIAL

SAMPLE INFORMATION

FARM ID

SAMPLED BY
☐ Grower ☐ NCDA&CS Agronomist
☐ Advisor ☐ Coop. Ext. Agent

SAMPLE DATE

COUNTY *(where collected)*

NUMBER OF SAMPLES

PAYMENT

FEE TOTAL _____
AMT PAID _____
METHOD OF PAYMENT
( ) CASH
( ) CHECK *(payable to NCDA&CS)*
( ) MONEY ORDER
( ) ESCROW *(provide account name below)*

GROWER INFORMATION *(please print)*

LAST NAME FIRST NAME

ADDRESS

CITY STATE ZIP

PHONE
(_ _ _) _ _ _ – _ _ _ _

E-MAIL ADDRESS ☐ **Do Not** notify me when report is available.

CONSULTANT/OTHER RECIPIENT

LAST NAME FIRST NAME

ADDRESS

CITY STATE ZIP

PHONE
(_ _ _) _ _ _ – _ _ _ _

E-MAIL ADDRESS ☐ **Do Not** notify me when report is available.

LAB NUMBER (leave blank)	SAMPLE ID	CROP NAME	GROWTH STAGE	WEEK	PLANT PART	PLANT POSITION	CORRESPONDING SAMPLE ID SOIL	SOLUTION	WASTE	PLANT APPEARANCE	SPECIAL TESTS ($2 EACH) Mo	Cl^-	NO_3	OTHER
1														
2														
3														
4														
5														

GROWING CONDITIONS

Planting date:
How long have symptoms been present?
Are plants infected with disease? Yes No
Are plants infested with insects? Yes No
Environmental conditions in last three weeks:
Rainfall Below normal Normal Above normal
Temperature Below normal Normal Above normal

IRRIGATION (AMOUNT): **TYPE:**
FUNGICIDES USED: **DATE:**

PROBLEM SAMPLE COMMENTS

FERTILIZER HISTORY

	Date	Material	Rate	Comments
Preplant:				
Postplant:				
Micronutrient:				
Other:				

Thank you for using agronomic services to manage nutrients and safeguard environmental quality. — Steve Troxler, Commissioner of Agriculture

INSTRUCTIONS FOR COMPLETING THE INFORMATION FORM

SAMPLES WILL NOT BE ANALYZED UNLESS ALL INFORMATION REQUESTED IN THE SHADED AREAS ON THE FRONT OF THIS FORM IS PROVIDED.

SAMPLE TYPE

Predictive analysis checks nutrient content and provides interpretation and general recommendations.
Diagnostic analysis identi es nutritional problems and provides interpretation and speci c recommendations.
Research is for samples submitted in connection with an approved research contract agreement.
Out of state is for samples submitted by non–North Carolina residents.

SAMPLE INFORMATION — Provide **FARM ID** (if applicable); details about sample collection (collector, date, number of samples and county where collected); and **PAYMENT** details: **Cost per sample = Base fee** [$5 for N.C. residents; $25 for out-of state samples; $12 for research samples] **+ $2 for each mandatory special test** [a petiole nitrate test is required for cotton and plasticulture strawberry; a molybdenum test is required for alfalfa, broccoli, all kinds of cabbage, cauli ower, collards, kale, poinsettia, spinach and turnip greens] **+ $2 for each optional test requested** [petiole nitrate, molybdenum and/or chloride). Be sure to indicate payment **TYPE**: check, money order, cash or escrow.

GROWER INFORMATION — Provide phone number with area code, mailing address and e-mail address (as an additional way for the lab to contact you, if necessary).

CONSULTANT/OTHER RECIPIENT — Provide indicated contact information for any partner/advisor who may need access to your test results.

SAMPLE ID — Provide sample identi cation (no more than six digits or letters). Put the same ID on the sample envelope.

CROP NAME — Enter the name of the crop sampled. You can use the common and/or botanical name.

GROWTH STAGE — Identify plant growth stage by one of these letter codes: **S = Seedling, E = Early growth, B = Bloom, F = Fruiting, M = Mature.**

WEEK — ***(necessary for cotton and strawberry only)*** Indicate the estimated number of weeks that the crop has been in the current growth stage.

PLANT PART — Identify the part of the plant that was sampled by one of these letter codes: **W = Whole plant** (from 1" above the soil line)**, T = Top three inches, E = Ear leaf, M = Most recent mature leaf** (including petioles for appropriate crops)**, H = Harvested leaf**, **P = Petiole only** (applies only to vinifera grapes at this time). For most plants, the most recent mature leaf (**M**) is the proper plant part to sample.

PLANT POSITION — Identify the position on the plant where the sample was taken by one of these letter codes: **U = Upper, M = Middle, L = Lower**. For most plants, the upper (**U**) position is the proper place to sample.

CORRESPONDING SAMPLE ID — List the IDs of any matching soil, solution or waste samples submitted.

PLANT APPEARANCE — Describe the symptoms of the plant at sampling. **If this space is left blank, we assume growth is normal.**

SPECIAL TESTS — Indicate additional mandatory or desired tests. Read the information above under **SAMPLE INFORMATION** for details.

GROWING CONDITIONS — Provide all requested information.

IRRIGATION (AMOUNT) — Provide this information, if applicable.

FUNGICIDES USED — Provide this information, if applicable.

PROBLEM SAMPLE COMMENTS — Provide additional information needed to help diagnose speci c problems.

FERTILIZER HISTORY — Provide all requested information.

Please do not place samples in plastic bags.
Leave ample air space in paper containers to promote drying and avoid sample deterioration.

NCDA&CS Agronomic Division 1040 Mail Service Center, Raleigh NC 27699-1040 (919) 733-2655 www.ncagr.gov/agronomi/

Understanding the Plant Analysis Report

Healthy plants contain predictable concentrations of the elements (nutrients) required for normal growth and development. Plants need primary nutrients (N, P, K) in greatest quantities, secondary nutrients (Ca, Mg, S) in lesser quantities and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl) in very small amounts (Table 1). Plants get all these nutrients from fertilizer and/or the soil. Three other elements that plants need—hydrogen, oxygen and carbon—come from water and the atmosphere.

Standard plant analysis measures concentrations of 11 essential elements (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B). Additional tests can be requested to measure Cl and Mo. Concentrations of primary and secondary nutrients are reported as percentages; micronutrient concentrations are reported in parts per million (ppm). The plant analysis report also presents results as index values that make it easy to interpret results in terms of plant health and productivity. The concentration for each element is converted into an index value (0–124), which falls into one of five interpretative categories (Figure 1).

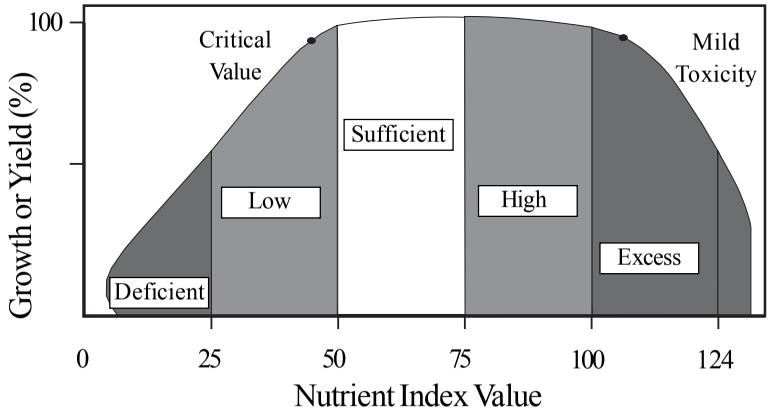


Figure 1. Nutrient Index Interpretation Scale

An index of 50–74 indicates that the nutrient concentration is *sufficient* for optimum growth and yield. *Low* (25–49) and *deficient* (0–24) index values indicate that the nutrient concentration is below the desired level and may be contributing to reduced growth, yield and/or quality. In such cases, supplying that nutrient to the crop at the optimum time and under optimum environmental conditions will result in an increase in growth and/or yield (Table 2).

Values in the *high* range (75–99) are not normally detrimental to growth or yield but, under some circumstances, may negatively impact crop quality. When values are in the *excess* (100+) range, growth problems may result due to nutrient imbalances or, in the case of micronutrients, toxic reactions. Values above 75 may indicate overfertilization and poor allocation of resources.

The critical value indicates the point at which a nutrient shortage causes a 5 to 10% loss in yield or growth; the point of mild toxicity indicates the same degree of loss due to nutrient excess. As the index decreases below the critical value or increases above the mild toxicity point, growth or yield will continue to decrease proportionately. The N:S, N:K and Fe:Mn ratios listed on the report indicate degree of balance among some essential elements.

Table 1. Nutrient abbreviations

N	Nitrogen	**Fe**	Iron	**Cl**	Chloride
P	Phosphorus	**Mn**	Manganese	**Na**	Sodium
K	Potassium	**Zn**	Zinc	**Ni**	Nickel
Ca	Calcium	**Cu**	Copper	**Cd**	Cadmium
Mg	Magnesium	**B**	Boron	**Pb**	Lead
S	Sulfur	**Mo**	Molybdenum	**NO_3-N**	Nitrate nitrogen

Table 2. Expected response to nutrient applications

Index	0–24	25–49	50–74	75–99	100–124+
Interpretation	Deficient	Low	Sufficient	High	Excess
Crop Response	High	Medium	Low	None	None

TABLE 4-3. FERTILIZER SUGGESTIONS FOR SMALL FRUIT

Purpose	Material	Amount	Precautions and Remarks
STRAWBERRIES, Matted-row			
Growth of new planting	N	30 to 40 lb N/acre	Apply in May and repeat in August or September on sandy soils. An additional 20 to 30 lb N per acre may be applied in January.
	P_2O_5, K_2O, and lime	Depends on soil test	Test before planting and apply P_2O_5, K_2O, and lime based on soil test.
Growth and fruit development	N	30 to 40 lb N/acre	Apply in August or September and in sandy soils again in January.
	N, P_2O_5, and K_2O	300 to 400 lb 10-10-10	Apply after harvest. If soil test for P and K are high, 30 to 40 lb of N may be used rather than 10-10-10.
STRAWBERRIES, Plasticulture			
Preplant (fall)	N	60 lb/acre	Broadcast and incorporate before bedding. Ammonium nitrate or a complete fertilizer (if P and K recommended) may be used.
	P_2O_5, K_2O, and lime	Refer to soil test. If not available, apply 60 lb P_2O_5 and 120 lb K_2O/acre.	Soil test before planting. Broadcast and incorporate before bedding. Apply lime 3 months before planting.
Preharvest (spring)	N	1/2 to 1 lb/acre/day (3.5 to 7 lb/acre/week); depending on petiole nitrate test	Begin biweekly tissue testing when plants begin growing in the spring. Adjust rate or omit applications depending on tissue test interpretation. Another option is to is to apply recommended N in three or four applications over a 12-week period (3- or 4-week interval) beginning with first growth.
	Other nutrients	Depends on tissue test	Biweekly tissue tests will indicate need. If B is needed, apply at 1/8 lb B per acre.