Producing Tobacco Transplants in Greenhouses

Water Quality

In recent years, more and more North Carolina tobacco growers have been producing tobacco transplants in greenhouses rather than in outdoor plant beds. Greenhouse transplants are more uniform, are easier to germinate and maintain, and may be started later in the season in the controlled greenhouse environment. In addition, labor costs for greenhouse production are lower than for plant bed production. This publication is the third in a series on greenhouse transplant production. It discusses the sources and quality of water essential to success in economically producing uniform, high-quality transplants.

Water quality is an important aspect of greenhouse transplant production. Regardless of the source, all water contains some impurities, typically consisting of elements and chemical compounds such as sodium, chloride, iron, boron, and bicarbonate. Some of these substances (boron, for example) can be beneficial to plant growth when present in small quantities. Others can be detrimental. Carefully selecting the water source, having water samples analyzed, and taking corrective measures when necessary are essential to successful transplant production.

Water Source

A well is the most desirable water source. Water from shallow wells is generally of acceptable quality; water from deep wells may be of poor quality in certain areas of the state. Municipal water that has been treated and filtered varies in usability for transplant production, depending on the area of the state and the source of the water.

Surface water is much more likely than well water to contain excessive levels of iron, which can lead to iron toxicity in seedlings. It is also likely to carry tobacco diseases; black shank has been reported on seedlings when pond and river water have been used. In addition, surface water may contain harmful herbicides that have entered the water in surface runoff from nearby agricultural fields. For all of these reasons, the use of surface water should be avoided if at all possible.

Water Sampling

Transplant production can be successful using water containing a wide range of components if a sample is analyzed and corrective action is taken before seeding. The North Carolina Department of Agriculture (NCDA) analyzes water samples at a moderate cost. Forms and information on collecting and submitting samples are available from county Cooperative Extension Centers. When the analysis has been completed, you will receive a detailed report with a recommendation concerning the suitability of the water for transplant production and any corrective action that may be necessary.

To have your water tested, collect a 16-ounce sample from each potential water source. A clean plastic soft-drink bottle with a screw-on cap makes an excellent sample container. Rinse the bottle several times (but do not wash it with soap) before use. Allow the water source to run for several minutes before collecting the sample. For recently constructed wells, let the water run at least 30

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Table 1. Desirable Characteristics for Water Used in Greenhouse Tobacco Transplant Production Systems

Component	Desirable Range	Component	Desirable Range
Nitrate Nitrogen (mg/L)	0-5	Sodium adsorption ratio (SAR)	0-4
Phosphorus (mg/L)	0-5	Electrical conductivity (mhos x 10^{-5}/cm))	0-75
Potassium (mg/L)	0-10	Total carbonates (TC) (meq/L)	0-2
Calcium (mg/L)	20-100	Alkalinity ($CaCO_3$) (mg/L)	0-100
Magnesium (mg/L)	6-25	Chloride (mg/L)	0-70
Sulfur (mg/L)	0-25		
Iron (mg/L)	0-2	Sodium (mg/L)	0-70
Manganese (mg/L)	0-2	Aluminum (mg/L)	0-5
Zinc (mg/L)	0-2	Fluoride (mg/L)	0-1
Copper (mg/L)	0-2		
Boron (mg/L)	0-2		
Molybdenum (mg/L)	0-0.1		

minutes to flush the system of impurities from new piping and water purification treatments that might lead to an incorrect analysis.

Desirable ranges for several components of importance in greenhouse water are listed in Table 1. The following sections discuss some common water quality problems and the steps that can be taken to correct them.

Bicarbonate

Water from some sources is high in carbonates, most of which occur in the form of bicarbonate salts. Recent research has shown that excessive levels of bicarbonate are very detrimental to seedling growth, as shown in Table 2. Seedlings produced with water containing bicarbonate at concentrations greater than about 2 milliequivalents per liter (meq/L) are stunted, yellow, and have small, brown root systems. Their leaves are often cupped downward. High-bicarbonate water can be made suitable for transplant production by adding acid to neutralize some of the bicarbonate.

Alkalinity and pH Adjustment

Water can be acidic, neutral, or basic (alkaline), depending on the chemical elements and compounds that it contains. Acidity and basicity are indicated by a unit called pH, which ranges from 0 (highly acidic) to 14 (highly basic or alkaline). A pH of 7 is neutral. Alkalinity indicates the water's tendency to neutralize acids or resist pH change when an acid is added. Carbonates, bicarbonates, and hydroxides are the major contributors to alkalinity. Alkalinity can be expressed in terms of calcium carbonate ($CaC0_3$) equivalent in parts per million (ppm) or as the concentration of total carbonates in milliequivalents per liter (meq/L). Alkalinity in parts per million of calcium carbonate can be converted to total carbonates (TC) by this formula:

$$TC = \text{alkalinity} \times 0.02$$

When an acid is added to water, the pH is reduced. This reduction in pH is a result of the neutralization of carbonate ($C0_3^{=}$), bicarbonate ($HC0_3^-$), and hydroxide (OH^-).

Sulfuric acid (H_2SO_4) is commonly used to neutralize alkalinity. It can be obtained as ordinary battery acid or as 93 percent reagent-grade acid.

Acid strength is measured in terms of its *normality,* expressed by the unit N. Battery acid is 9.19N sulfuric acid. Commercial 93 percent sulfuric acid is much stronger: 34.7N. Both are frequently used to reduce transplant water acidity. One unit (1 meq/L) of acid will neutralize one unit (1 meq/L) of alkalinity.

CAUTION: Use extreme care when mixing acid and water. The chemical reaction can cause acid to splash into the eyes or onto skin and clothing. ALWAYS ADD THE ACID TO THE WATER, NOT THE REVERSE. Add the acid slowly in very small portions and mix thoroughly before adding more. WEAR SAFETY GOGGLES AND PROTECTIVE CLOTHING. Have a large supply of clean water readily available to flush any area of the body contacted by the acid. Do not work alone; have an assistant nearby who can summon medical assistance if necessary.

Formulas have been derived to compute the amount of acid to add to a volume of water to neutralize a given level of alkalinity (total carbonates). The following are

Table 2. Effect of Bicarbonate Content of Water on Seedling Growth and Usability in a Float System					
Bicarbonate Concentration		Fresh Weight	Dry Weight	Stem Length	Percentage of Usable
(meq/L TC)	(ppm $CaCO_3$)	(grams/plant)		(cm/plant)	Transplants
0	0	6.3a	0.46a	6.3a	58a
2	100	5.6a	0.38ab	5.3b	53a
6	300	3.9b	0.34b	2.0c	17b
10	500	0.0c	0.0c	0.0d	0c

Note: Means followed by the same letter are not significantly different at the P = 0.05 level.

simplified versions of these formulas and are correct when used to neutralize 80 percent of the carbonates as recommended by the NCDA.

1. For alkalinity expressed as parts per million (ppm) or milligrams per liter (mg/L) of $CaCO_3$:

$$V = \frac{0.204\,(CaCO_3)}{N}$$

Where:

V = ounces of acid to add to 100 gallons of water

N = Normality of the acid

$CaCO_3$ = Alkalinity expressed as parts per million of calcium carbonate

2. For alkalinity expressed as milliequivalents per liter (meq/L) of total carbonates:

$$V = \frac{10.2\,TC}{N}$$

Where:

V = Ounces of acid to add to 100 gallons of water

N = Normality of the acid

TC = Total carbonate concentration in milliequivalents per liter (meq/L)

To see how the calculations are performed, consider these examples:

1. You have a water source with an alkalinity of 300 parts per million $CaCO_3$ equivalent.

For neutralization with battery acid (9.19N):

$$V = \frac{0.204\,(300)}{9.19} = \text{6.7 ounces of battery acid per 100 gallons of water}$$

For neutralization with 93 percent sulfuric acid (34.7N):

$$V = \frac{0.204\,(300)}{34.7} = \text{1.8 ounces of 93 percent sulfuric acid per 100 gallons of water.}$$

2. You have a water source with an alkalinity expressed as 8 milliequivalents of total carbamates per liter.

For neutralization with battery acid (9.19N):

$$V = \frac{10.2\,(8)}{9.19} = \text{8.9 ounces of battery acid per 100 gallons of water}$$

For neutralization with 93 percent sulfuric acid (34.7N):

$$V = \frac{10.2\,(8)}{34.7} = \text{2.4 ounces of 93 percent sulfuric acid per 100 gallons of water}$$

Fertilization and Alkalinity

A number of fertilizers can be used to provide the nutrients needed in float production systems. A 150-ppm nitrogen concentration at seeding obtained by dissolving a material like 20-10-20 fertilizer in the water followed by an additional 100 ppm of nitrogen at four weeks produces good quality transplants. Plants respond best in alkaline water when at least 75 percent of the nitrogen is in the nitrate form rather than other forms. Nitrogen can be lost through volatilization when a large proportion of the nitrogen is in the urea or ammonium forms.

Some fertilizers (such as 20-10-20, 20-20-20, and 21-5-20) are acidic, whereas others are alkaline. When the water is marginally alkaline (with a TC of 2 to 3 meq/L), an acid fertilizer can be used in preparing the nutrient solution so that the pH is also reduced. When the water is acid (pH 4.0 to 5.0), a basic fertilizer (such as 15-5-15) can be used so that the pH is adjusted upward.

When the water is only marginally alkaline (with a TC of 2 to 3 meq/L), be careful not to overacidify. Generally, either an acid treatment or an acid-forming fertilizer (not both) is required when alkalinity is marginally high. A solution sample should be tested a few hours after acid treatment or fertilization to confirm that the pH and nutrients are within the desired ranges.

Neutralization of alkalinity for water used in overhead-irrigated systems is equally important. Acid should be mixed with the water thoroughly before irrigation or feeding. Holding tanks provide the best means for mixing and allowing adequate reaction time for the acid. Many growers have installed injection systems that inject concentrated dosages of fertilizer into the water as it flows to the spray boom. This arrangement eliminates the need for large holding tanks. If water acidification is necessary, it is important to use *two* injectors, one for the acid and one for the fertilizer solution. Acid should *not* be added directly to the concentrated fertilizer solution.

Sodium

Tobacco seedlings in float systems are very tolerant to sodium. In a recent study, seedling growth was normal at sodium concentrations up to 500 ppm. However, sodium may alter physical properties of the medium and can interfere with calcium and magnesium uptake if the concentration of these elements in the water is less than the minimum values shown in Table 1. Sodium salts may also accumulate to excessive levels in the root zone, particularly in overhead-watered production systems. A good indicator of the sodium hazard of water is the sodium adsorption ratio (SAR), which is the proportion of sodium to calcium and magnesium. It should be less than 4.0.

If sodium levels are too high, adding calcium and magnesium will provide increased competition with sodium for plant uptake in both float and overhead-watered systems. In overhead-watered systems, it will also promote leaching of excess sodium from the cells. When sodium levels are high, the medium in trays should be kept moist to limit root injury. Calcium and magnesium can be added to nutrient solutions by using fertilizer with formulas such as 15-5-15 or 16-4-16 that contain these elements or by furnishing a portion of the nitrogen using calcium nitrate and adding magnesium sulfate (Epsom salts) to the solution.

Boron

Boron deficiency, which causes bud distortion and death, has been observed on flue-cured and burley seedlings grown in float systems in the piedmont and mountains. In all cases the water did not contain boron and the seedlings were held for an extended period in the greenhouse at very low fertility levels because field conditions were not suitable for transplanting. If an analysis indicates that the water contains little or no boron, use a fertilizer containing a trace level of this element to make up the nutrient solution. If a fertilizer with boron is unavailable, adding no more than 0.25 ounce of Borax or 0.125 ounce of Solubor per 100 gallons of nutrient solution is sufficient to prevent a deficiency.

Iron

Iron toxicity has been observed on young seedlings in overhead-watered systems when the water contained excessive concentrations of iron. Toxic levels of iron are generally associated with the use of surface water, which should be avoided for the reasons discussed previously.

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