Plant Available Nitrogen

Plant available forms of nitrogen (N) are inorganic and include nitrate (NO_3), and ammonium, (NH_4). Prior to analysis, soil samples should be air dried rather than oven dried at high temperature (> 30ºC) to prevent N loss through volatilization. Air drying soon after collection also inhibits transformations in N pools due to microbial action. Determination of these plant available forms of N are routinely done using a neutral salt (1*M* KCl) extraction followed by colorimetric analysis, usually with an automated analyzer. Colorimetric determination of inorganic N species can also be done on water samples (soil pore-water, leachate). These methods are fast, inexpensive and reliable.

Cautions for Disturbed/Restored Sites

Colorimetric methods for nitrite (NO_2) and nitrate (NO_3) are pH dependent so the samples should not be strongly buffered. Otherwise the analyst should be warned and can neutralize the samples prior to analysis. Acidification of water samples precludes the analysis of NO_2 *(Mulvaney, 1996)*.

Nitrogen Fertility

Most nitrogen fertility information is aimed toward agronomic crops. Local nitrogen fertilizer recommendations and estimates of N sufficiency and deficiency should be provided through the soil testing laboratory or through your local County Extension Office. In general, 100 to 300 lbs N A^{-1} should be sufficient for good grass growth (Johnson et al., 2000). While at inorganic N levels above this there may be an increased risk of NO_3 runoff and leaching.

Plant Available Phosphorus

Plant available phosphorus (P) is determined using a soil extraction followed by colorimetric or inductively coupled plasma atomic emission spectroscopic (ICP-AES) analysis. The three most common extractants used are Mehlich 3 (Mehlich, 1985), Bray P1 or Olsen (Kuo, 1996). Mehlich 3 and Bray P1 are acidic fluoride extracts while Olsen is 0.5*M* sodium bicarbonate ($NaHCO_3$) and the preference for one extract over another is determined by the soil characteristics and pH in a region. This may not be a valid criteria for a disturbed/restored site. The soil characteristics and pH of the site may be very different from those typical in the region and if possible the site characteristics should be used to determine which test is chosen. These issues should be discussed with the soil testing laboratory so they can provide guidance. For whichever method is chosen the fertilizer recommendations and determinations of sufficiency or deficiency are specific to the extract used, since they are calibrated with crop response. For example, extractable P levels considered sufficient for most crops are 24 lbs A^{-1} for Olsen P, 65 lbs A^{-1} for Mehlich 3 P and 50 lbs A^{-1} for Bray P1 extractable P (Havlin, 2004). Mehlich 3 has the added advantage of being reliable across a broad range of soil pH and also being

calibrated with crop response to determine soil sufficiency for Ca, K, Mg, Zn, Cu, and Mn.

Cautions for Disturbed/Restored Sites

Colorimetry should not be used for P determinations on sites where arsenic (As) is present. The P extractions will also extract As, so As is a major interference in P colorimetry. Rather than contend with this As interference, ICP can be used to determine P levels in extracts.

Plant Available Macro/Micro-Nutrients

Potassium (K), calcium (Ca), sulfur (S), phosphorus (P) and magnesium (Mg) are macro-nutrients important for plant growth and are routinely evaluated. Plant micro-nutrients routinely evaluated including boron (B) copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) are also essential for plant growth and. There are many macro/micro-nutrient soil tests developed regionally and calibrated with crop response, the preference for one test over another is determined by the soil characteristics, pH and climate in a region. This may not be a valid criteria for a disturbed/restored site. The soil characteristics and pH of the site may be very different from those typical in the region and if possible the site characteristics should be used to determine which test is chosen. These issues should be discussed with the soil testing laboratory so they can provide guidance. For whichever method is chosen, the fertilizer recommendations and determinations of sufficiency or deficiency are specific to the test used, since they are calibrated with crop response *(Havlin et al., 2004).*

Cautions for Disturbed/Restored Sites

Excessive levels or availability of some micro-nutrients (Zn, B, Cu, Mn) can be phytotoxic. While this is an unusual occurrence in natural soils it should be watched for on disturbed/contaminated sites. A good soil testing laboratory or the County Extension Office should be able to provide guidance.

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