Foliar-applied nitrogen fertilizers in spring wheat production

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The Northern Great Plains region is traditionally recognized worldwide for production of premium quality wheat. Spring wheat continues to be the key cereal crop for the region. While nitrogen (N) is considered the most common nutrient limiting yield of wheat and other cereal crops, N use efficiency (NUE) is currently only about 40 to 50% for most crop production systems (Gupta and Khosla, 2012). A substantial increase from the previously estimated 33% NUE in the late 1990s (Raun and Johnson, 1999) is primarily due to advances in precision nutrient management. Developing an effective N management system, improving N recommendations, and increasing NUE are central issues that should be addressed to maintain and increase the sustainability of wheat production in the future. Spring wheat’s primary value is its quality, represented by high grain protein content. Thus, when evaluating use efficiency for spring wheat, combining yield and protein into protein yield, as proposed by Jackson (2001), makes sense because N is vital to both yield and protein production. Continuous advances in novel fertilizer technologies, and the active promotion of liquid products as more efficient, have renewed growers’ interest in liquid fertilizers.

Foliar nutrition mechanisms and application conditions

The scientific community and crop producers alike are debating whether foliar-applied N fertilizers are more efficient compared with the soil-applied fertilizers. Plants are known to attain water and various solutes though foliage (Wittwer and Teubner, 1959). Permeation studies by Below et al. (1985) showed that leaf stomata facilitate the mineral nutrient uptake. Foliar fertilization can assist in correcting deficiencies or preventing nutrient shortages during critical growth stages due to rapid nutrient absorption and utilization. On the other hand, unlike roots, plant leaves are not adapted to take up great volumes of nutrients and to meet the bulk of the nutrient requirement (Mikkelsen, 2008). The recent work by Fernandez et al. (2013) outlines the four consecutive steps of foliar nutrition as adsorption (adherence to the leaf surface), movement through the leaf surface, absorption (cellular compartmentalization), and translocation and utilization by the plant. Work by Stiegler et al. (2011) in bermuda-grass, Angus and Fischer (1991) in winter wheat, and Woolfolk et al. (2002) in spring wheat showed that 25 to 55% of foliar-applied N is taken up through the leaves. Ling and Silberbush (2002) noted that nutrient interaction must be taken into account when several nutrients are supplied as a complex foliar fertilizer because one nutrient may enhance or inhibit the uptake of another nutrient. Finally, studies by Angus (2011) illustrated those foliar fertilizers are likely to be cost effective if the price of foliar products is no more than 15% greater than traditional granular fertilizer sources such as urea.

Potential and challenges of foliar nutrition

Some support the idea that the application of N fertilizer to the leaves is more efficient because the many possible pathways for N loss, associated with the application of nutrients to the soil, are avoided (Mosali et al., 2006). Instead, N is directly “fed” to the plant, and the available N is readily taken up, translocated, and utilized. Therefore, smaller amounts of fertilizer should be sufficient to satisfy crop N requirements and to effectively correct N deficiency midseason. Some advantages of foliar fertilization according to market media include: immediate benefits, prolonged flowering, increased yields, enhanced growth during dry spells, increased cold and heat tolerance, increased pest and disease resistance, maximized plant health and quality, and improved internal circulation of the plant (Chalker-