Application of Humic Substances in Agriculture

A Partial Bibliography of Recent Humic Literature

Compiled by the Humic Products Trade Association

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- Early evidence that humic substances support plant growth
    - For an extensive review of how humic products are used in agriculture, see (MacCarthy and Rice, 1994).

- Recent field trials
    - A randomized complete block replicated green house and field experiment on grassland pasture, potatoes, and maize showed that the application of liquid and dry humic substances had an overall positive effect on crop yield. The formal meta-analysis revealed an increase in nitrogen, phosphorus, potassium and magnesium in all of the crops, demonstrating a more efficient use of fertilizers. There was a substantial increase in grass production for the treated plants when subject to heat and water stress (drought).
    - Application rate of 60 mg of humic acid per kilogram of soil generated the largest increase in height, weight and nutrient uptake in wheat grown on the soils when compared to applications of 30 and 90 mg/kg. The humic acid application significantly improved soil potassium, phosphorus and nitrate concentrations in both calcareous and non-calcareous soils (Tahir et al, 2011).
    - Brownell et al (1987), reported average yield increases of 10.5% and 11.2% in replicated field trials for tomatoes and cotton respectively, and an average 25% increase in grape production on unreplicated large scale field trials of differing grape varieties in different vineyards.
    - After a thorough review of the literature and performing numerous experiments, Chen et al (2004a) concluded that humic substances at an application rate of 67.5 kg ha^{-1} (59.4 lb a^{-1}) and foliar application of humic and fulvic acids at 375 g ha^{-1} will affect plant growth.

- Modes of action and Mechanisms
    - Enhanced nutrient uptake
        - The benefits of humic substances in agricultural soils is well established (MacCarthy, 2003) especially in soils with low organic matter (Chen and Aviad, 1990).
        - The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as

nitrogen, phosphorus, sulfur (Chen and Aviad, 1990) and micronutrients, i.e. Fe, Zn, Cu and Mn. (Chen et al, 1999).
        - Humic substances act as a storehouse of N, P, S, and Zn (Frank and Roeth, 1996).

- Nitrogen management
    - Humic acids may improve urea nitrogen use efficiency as well as reducing environmental pollution by increasing soil exchangeable NH4 + and available NO3 - while retaining more nitrogen in the soil (Yusuff et al 2009).
    - The importance of humic substances on the fertility of soils and the stabilization of nitrogen has been well documented (Thorn, 2000; Kelly and Stevenson, 1994; Nardi, et al, 1996).
    - After 45 years of research, C. Edward Clapp of the USDA-ARS, Department of Soil, Water & Climate in Minneapolis, Minnesota, has recommended the use of humic substances to prevent nitrogen leaching on golf courses (Clapp, 2001).
    - Humic acids stimulate nitrifying bacteria (Vallini et al, 1997)

- Phosphorus management
    - Humic substances have the ability to stabilize phosphorus fertilizers (Day, et al, 2000)
    - Humic substances keep minerals in soil solution keeping them from precipitating with soil iron and aluminum through complexation reactions (Tan, 1986; Banfield and Hamers, 1997; Schnitzer, 1986), and interactions with other common soil elements, especially the lanthanide elements, which are effective in stabilizing phosphorus in soil systems (Banfield and Hamers, 1997).

- Soil Physico-Chemical Interactions
    - Humic substances can improve water holding capacity for better drought resistance and reduction in water usage (Russo and Berlyn, 1990).
    - Good soil structure is influenced by humic substances participating in numerous bridging mechanisms, including water, aluminum, and calcium bridging (Tan, 2003, pp. 250-253).

- Plant growth stimulants
    - Stimulation of root growth is generally more apparent than stimulation of shoot growth. (Chen and Aviad, 1990; Nardi, et al, 1996; Abad et al, 1991).

- The addition of humic substances to soils, including calcareous soils, can stimulate growth beyond the effects of mineral nutrients alone (Chen, et al, 1999).

- Microbial Stimulants
  - Humic substances enhance the uptake of minerals through the stimulation of microbiological activity. (Albuzio et al, 1994; Figliolia et al, 1994; Visser, 1985; Nardi, et al, 1996; Paciolla, et al, 1998: Day et al, 2000).
  - Enzyme activity is preserved by humic substances, imparting a high degree of resistance to decomposition and denaturing, allowing enzymes to persist for many years in soils (Jackson, 1995).

- Mechanisms
  - Plant growth stimulation by humic substances at extremely low concentrations has been explained as a hormonal-like growth effect by numerous authors (Xunzhong Zhang and Schmidt, 2000; Nardi et al, 2002; Basiolio et al, 2007; Aguirre et al, 2009).
  - Chelation and complexation by humic substances keeps plant nutrients in soil solutions (Tan, 1986; Chen, et al, 1999; Clapp, et al, 1998).
  - Humic substances at low concentration (10 µg of organic carbon mL-1) in deionized water, stimulated the release (efflux) of H+ protons from oat roots, significantly decreasing the water pH, supporting the concept that humic substances either directly or indirectly acidify the rhizosphere, helping to explain why humic substances are used to increase fertilizer efficiency (Pinton et al, 1997).

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