

6. Regulatory and environmental considerations

In this chapter a brief account of the status of foliar nutrient sprays within the existing fertilizer regulation will be provided with emphasis on the environmental impact associated with foliar fertilization.

6.1. Regulatory matters

This overview of current fertilizer legislation has been written based upon discussions with Prof. Juan José Lucena (Universidad Autónoma de Madrid). Currently, within the European Union (EU) and the United States (US) there are no specific regulations for foliar fertilizers other than those developed for fertilizers as a whole. Regulations governing fertilizers vary between countries and states and there are currently no general or standard protocols agreed upon for chemicals to be designated as fertilizers. For example, there are many products currently certified as fertilizers in the United States that are not yet permitted for use in the European Union. This is particularly true in the realm of products acceptable for use in organic agriculture. A consequence of these disparate guidelines is that manufacturers must approach registration separately and agriculturalists must validate the efficacy of all products in each jurisdiction. For instance, the terms ‘complex’ or ‘chelate’ are widely used throughout the industry but as there is no requirement that these terms be used in accordance with their true chemical meaning the occurrence of these terms on material or product labels should be interpreted with caution.

In the EU, regulation (EC) N° 2003/2003 and its subsequent technical amendments known as ATP's (Adaptations to Technical Progress) are used to approve fertilizers that comply with these conditions. Since 2003 a number of amendments (with a fifth and sixth to appear shortly) have been approved and subsequently implemented with the aim of promoting the effectiveness and purity of fertilizers as well as the standardization of products and analytical techniques to assess their quality. China, India, Australia and some other countries have regulations in place to ensure quality and efficacy of fertilizers to greater or lesser degrees. In the US, regulations mandate that fertilizer labels accurately reflect nutrient contents and meet the standards for heavy metal contamination only. Currently, there are no US regulations that require a demonstration of effectiveness of a fertilizer product as a nutrient source.

The European fertilizer legislation complies with the legal requirements established in all European countries but it may be superseded by national fertilizer regulations that may allow or disallow the use of nutrient compounds not regulated by the

European Union. The regulation of fertilizers within the European countries enables the occurrence of “legal windows” to introduce products that may otherwise not be allowed by Regulation (EC) N° 2003/2003 and its consequent ATP’s.

6.2. Environmental and food quality considerations

Generally speaking, and when applied alone the environmental impact of foliar fertilizers is lower than that of most soil-applied fertilizers and leaf-applied plant protection products primarily because amounts applied are lower and the risk of soil or water contamination is minimized. However, since agricultural sprays are often supplied as agrochemical mixtures that may include foliar nutrients and plant protection products together, care should be taken to avoid environmental contamination. In Chapter 5, the technology of foliar application was discussed and referred to the rising concern about spray drift from plant protection products which is leading to the gradual implementation of control policies in many areas of the world as described by Hewitt (2008) and van de Zande *et al.* (2008a). These restrictions may impact upon the use of foliar fertilizers both by limiting their use in tank mixes with other agrochemicals and indirectly by affecting public perception of field spraying activities in general.

Foliar nutrients may benefit the environment by enhancing the efficacy of plant protection chemicals. The synergistic effect of mineral nutrients when applied in combination with plant protection products has been shown in several investigations (Dordas, 2009; Elattal *et al.*, 1984; Moustafa *et al.*, 1984; Simoglou and Dordas, 2006). In addition, the plant protection effects of several foliar-applied macro- and micro-nutrient solutions, including silicon based compounds, has been described, especially in relation to the control of fungal diseases (Dordas, 2009; Reuveni and Reuveni, 1998a; Reuveni and Reuveni, 1998b). Recently, Deliopoulos *et al.* (2010) reviewed the existing literature to analyze the effect of 34 inorganic salts (chiefly bicarbonates, phosphates, silicates, chlorides and phosphites) that were reported to reduce the severity of 49 fungal diseases in 35 plant species, and concluded that they were generally less effective in controlling fungal diseases than conventional fungicides and therefore cannot fully replace them. However, it was suggested that application of inorganic salts in a disease management strategy may enable a reduction in the number of conventional fungicide applications required (Deliopoulos *et al.*, 2010), and the supply of nutrients may improve the tolerance or resistance mechanisms of the host plant to pathogens (Dordas, 2009). Balanced nutrition is clearly an essential component of any integrated crop protection programme (Datnoff, 2007) but more research is required to fully realize the potential of foliar mineral element sprays as tools to reduce the effect of biotic stress in plants.

Phosphite has been recognized to have antifungal properties but there is controversy concerning the potential of this chemical to provide P to plants (Lovatt, 1990). Recently, it has been suggested that it should not be classified as a foliar fertilizer due to the high phytotoxicity risk from its application (Ratjen and Gerendas, 2009).

- Foliar fertilizers are often applied alone and as such they have a low environmental impact.
- When supplied in combination with plant protection products problems associated with spray drift may occur.
- Foliar fertilizers may have a synergistic effect when applied together with fungicides or pesticides.
- Several foliar-applied inorganic compound solutions have been reported to limit the effect of biotic stress in plants.

There are only a few studies reporting the occurrence of foliar spray residues and subsequent damage to marketability and safety of horticultural commodities. Application of in-season P-based foliar fertilizers to apple trees led to the occurrence of P-acid residues in apples at the time of harvest (Malusa and Tosi, 2005; Tosi and Malusa, 2002). Cheng and Crisosto (1994) showed that high concentrations of surface Fe and Al contaminants, in combination with abrasion (as may occur to the fruits during transportation), induced 'skin-inking' of peach and nectarine. In the light of these observations, Crisosto *et al.* (1999) recommended avoiding the application of foliar-nutrient sprays containing heavy metals particularly Fe but to a lesser degree Al and Cu in decreasing order for inducing fruit 'skin-inking' within 22 days before harvest.

- In general, and when applied alone, foliar fertilizers are not prone to cause food safety risks or produce marketability problems.

The beneficial effect of applying nutrients as foliar sprays in terms of improved effectiveness and limited environmental pollution as compared to soil-applied fertilizers has been illustrated by several authors (Kannan, 2010). Johnson *et al.* (2001) suggested that supplying N to peach trees using a combination of soil and foliar N fertilizers leads to optimal plant responses and limited environmental pollution risks. This approach has also been supported by others (Dong *et al.*, 2002; Dong *et al.*, 2005b) who demonstrated the effectiveness of foliar applications of urea in autumn as a strategy to increase tree N storage and to limit NO₃-N leaching problems associated with soil N fertilization. Stiegler *et al.* (2011) measured minimal NH₃-N volatilization losses when urea was applied to the foliage of actively growing turf grass. The authors highlighted the potential for minimizing N losses to the environment and increasing application efficiency through the use of foliar N fertilization on high-density golf courses. A similar efficacy relationship between foliar and soil K fertilization was demonstrated in rainfed olive trees grown in arid and semi-arid regions (Restrepo-Diaz *et al.*, 2009) in order to avoid problems associated with low K root uptake under limited soil moisture conditions. Similarly, a benefit of foliar P nutrition in dry-land cereal crops may occur when soil surface layers become dry thereby reducing the efficacy of surface P applications (Noack *et al.*, 2011).

- Foliar fertilization has a lower environmental risk in contrast to soil applications.
- Nutrients are delivered to target organs by spraying.
- A combination of foliar and soil treatments can help to increase nutrient uptake efficiency and limit soil pollution, particularly with elements such as N and/or P.

6.3. Conclusions

In this chapter, the regulation of foliar fertilizers and the potential environmental and food quality risks have been evaluated. In light of the current knowledge and understanding, the following certainties, uncertainties and opportunities for the regulation and risk potential of foliar fertilizers can be addressed.

Certainties

- There are currently no specific regulations governing foliar fertilizers.
- Products are classified according to a list of active ingredients allowed as fertilizers.
- When applied alone foliar fertilizers have a low environmental impact.
- Fertilizer/plant protection product mixtures are often applied to the foliage with the consequent spray drift and pollution risk.
- Certain nutrient element compounds can have a synergistic effect when applied together with fungicides or insecticides.
- Some nutrient element compounds can have a plant protection effect (e.g. fungicidal) when sprayed to the plants.
- Foliar nutrient fertilizers applied alone generally do not represent food safety risks.
- Many reports provide evidence for the lower environmental impact of foliar sprays as compared to soil treatments.

Uncertainties

- Since there are currently no specific regulations for foliar fertilizers it is difficult to standardize the many foliar fertilizer products available on the market.
- The process of introducing new foliar fertilizers in the market is complex.
- The effects of combined fertilizer/plant protection products cannot be predicted *a priori*.
- Several reports provide evidence for the beneficial effect of spraying nutrient element solutions to the foliage as a tool to control plant disease but the mechanisms involved are currently not fully understood
- The use of foliar fertilizers as a complementary strategy to reduce soil applications and pollution has not been fully exploited in agricultural production.

Opportunities

- By introducing regulations specifically for foliar fertilizers it might be possible to standardize and categorize the commercially available products and better focus scientific research and field practices to improve the overall performance and efficacy of foliar nutrient sprays.
- Knowledge of the synergistic effect of certain plant nutrient compounds when applied together with plant protection products may help to optimize the concentration of agrochemicals applied to plants and therefore reduce their environmental impact
- The beneficial effect of foliar-applied nutrients in reducing plant biotic stress should be further elucidated and implemented in agriculture.
- The low food safety and environmental risk of foliar-applied fertilizers have proven advantageous for agricultural and horticultural production.
- As a complementary strategy to soil treatments foliar nutrient sprays can help reduce nutrient run-off and leaching from soils and thus reduce contamination of water tables.