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Fertilizer Focus

Improving efficiency of organo-mineral fertilizers

Written by

Bruno Daridon, *Plant-Care R&D Manager,* ***Olmix, France***

Plant nutrition has for a long time been managed by fertilization in combination with agricultural practices such as inter-cropping/ green-covers or recycling of crop residues for maintaining a good organic matter soil status. Depending on farmer strategy and on the availability of local raw materials, farmers can use mineral fertilizers, organic matter from cattle/animal production or organo-mineral fertilizers for providing good plant nutrition and crop productivity.

Solieria chordalis *(Source: Olmix)*

For field crops, long term soil fertility leverage needs to be addressed in order to maintain fertilizer efficiency and sustainable soil productivity. Farmers need to fuel the soil engine by practices that target soil nutrition by providing sufficient and qualitative organic matter inputs. Organic matter is a key nutrient pool providing benefits to crop productivity such as:

- Soil biological activity and diversity for resilience toward stresses
- Biological fertility for ecosystemic services
- Long term physical soil fertility for rooting
- Chemical fertility in the rhizosphere for plant nutrition

The agronomic bibliography largely supports these chain reactions on both scientific and practical application levels. There are numerous examples where production yield and quality are maintained at the same, or even improved, levels in spite of reduced NPK levels using organo-mineral fertilizer instead of mineral fertilization.

Given the system of 'soil biological activity + plant crop' we understand the importance of organic matter as the basis of fertility, and therefore the capacity of organo-mineral fertilization to fuel the soil food-web and at the same time provide fertilization for plant nutrition.

Mineral acquisition

It is generally considered that plant nutrition from roots represent 90-95% of the total mineral nutrient acquisition whereas foliar nutrient acquisition by leaf spraying brings no more than 5-10% of the total.

It is thus of prime interest to first address soil fertility and foliar fertilization as a complement. Foliar fertilization is not negligible though, especially when abiotic stresses are occurring or when soil flux is slowed down by drought. In contrast to the large differences in the contribution of soil versus foliar mineral nutrition, the foliar nutrition is faster and more efficient than soil nutrition because of the reactions that modify the mineral forms in the soil. Over time the soil reduces nutrient availability via lixiviation or volatilization, especially for nitrogen. These losses can be minimized by an optimal soil biological activity and by improvement of fertilizer use with fractionation of inputs and by localization of inputs.

Coming back to abiotic stresses and plant nutrition, liquid organo-mineral plant biostimulants containing mineral and oligoelements in combination with organic bioactives such as seaweed extracts provide interesting solutions for both leaf nutrition during key phenological crop stages and for promoting crop nutrition during abiotic stress episodes.

Sources of organic matter for organo-mineral fertilizers

The various sources of organic matter for commercial organo-mineral fertilizers are highly diversified depending on agronomic objectives and the agroindustry by-products availability in the area. We can segment organo-mineral fertilizers as follows:

- Granules for crop nutrition at short-middle term with high NPK containing raw materials like bone, meat, feather meals, oilseed cakes, molasses, poultry manure, ashes and struvite
- Soil improver pellets with low NPK containing raw-material, high C/N ratio and high ISMO indexes (Organic Matter Stability Index). These use products such as compost, lignocellulosic materials and agroindustry by-products
- Solid granules or microgranule soil biostimulants, promoting PGPR rhizospheric micro-organisms based on amino acids, humic acids, lignosulphonate and seaweed
- Liquid foliar organo-mineral biostimulants, containing seaweed extracts, amino acids, humic acids and plant extracts together with oligoelements. These biostimulants contribute both to plant nutrition and to plant resistance towards abiotic stresses
- Liquid soil organo-mineral biostimulants with fertilizers for improving soil NP acquisition, rooting and starter effects

Figure 1. N-tester index (chlorophyll estimation) during wheat drought stress experiment in controled conditions. Leaf treated objects are stimulated and recover better after drought than stress control

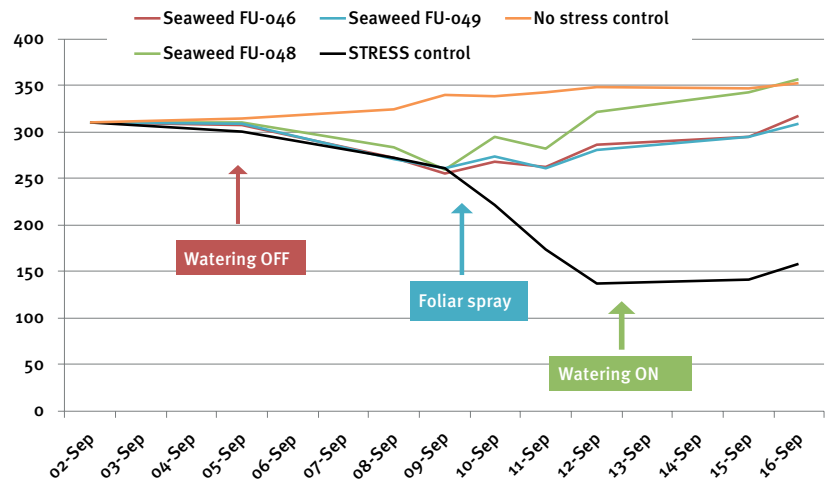
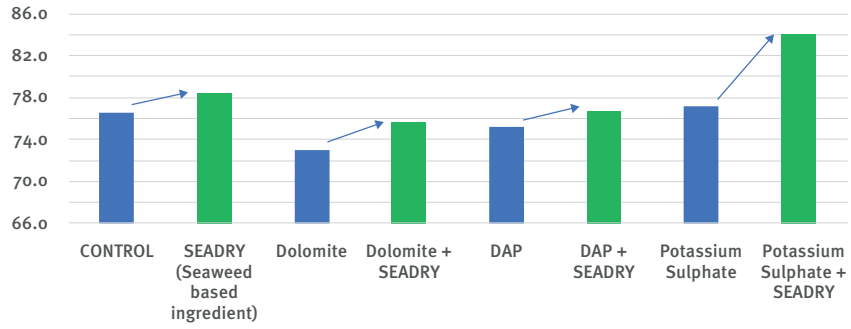


Figure 2. Corn yield (dt/ha) - Mean value of 4 field GEP trials with same protocole. Seadry Organic Matter biostimulant improves Mineral Fertilizers efficiency on corn (Dolomite, DAP, SOP)



Root mineral nutrition

The mineral fluxes from roots to plant are dependent on several factors with the most predominant being:

- Form of the mineral elements (chlorides, sulphate, nitrate, organic-complexes, natural carrier or chelate and synthetic chelates)
- Concentration of the available form of mineral element in the soil solution
- Soil biological activity, driven by the pool of organic matter, its quality and by microbial biodiversity
- Water availability, as a vehicle for mineral elements
- Physico-chemical soil conditions (pH, rH, oxygen, cationic exchange capacity and buffering and soil structure)

Inputs of fresh organic matter from organo-mineral fertilizers constitute a labile support and provides capacity for complexing mineral elements.

The input behaves as a short-term cationic exchange capacity buffer that keeps elements in the upper soil layers, thus feeding the root-zone during organic matter mineralization. Elements are delivered to the plant in parallel to feeding microbial biomass with a lower lixiviation risk compared to mineral elements salts. Organo-mineral fertilization thus directly impacts the first three points above.

Fertilizer formulation, product dosage and mode of application need to be optimized depending on crop needs and soil analysis/soil diagnostics are useful tools for fertilization decision making.

Foliar mineral nutrition

Foliar nutrition is ruled by leaf structure constraints. The mineral elements must penetrate several leaf layers: cuticule, cell-wall and cell membrane. Some crop species also have additional hydrophobic surfaces or hairy surfaces that constitute additional obstacles due to reduced wetting.

Leaf surface wettability can be improved with different organic molecules promoting water retention, for example hydrophilic molecules such as sugars, oligosaccharides, polysaccharides, polyols, amino acids, betaines and osmolytes that are natural humectants found in seaweed extracts. This is of great use for organo-mineral foliar fertilizers because they reduce droplet evaporation speed, giving the mineral elements more time to penetrate by keeping them soluble longer.

In plant biostimulant products, small organic molecules are also active and penetrate the plant derm to provide their biological effects.

Organo-mineral liquid formulations can have several functions: crop nutrition and plant biostimulation at the same time.

Examples of seaweed in organic fertilizers and biostimulants

Macroalgae represent a significant and cost effective organic raw material resource for agriculture because of the large and recurrent volumes of beach cast seaweed. Standing stocks can also be harvested. Alternatively, seaweed can be cultivated, but this method is still not competitive enough for fertilizer purposes. Harvesting of shored opportunistic seaweed is also an ethical way chosen by some companies such as Olmix. It is sustainable and reduces the negative impact of these beachings and it also does not alter the natural growing seaweed field resources.

Seaweed has been used for hundreds of years as soil amendment and as soil fertilizers in coastal regions in countries such as India, Spain, France, Ireland, Norway, Japan and Canada. Traditional agricultural uses have been further explored by scientists and agronomists with several pathways described.

Seaweed biomass contains minerals such as potassium, magnesium, calcium and sulphur in organo-mineral forms. Seaweed is also rich in rare oligoelements and the extracts can efficiently provide these elements to plants and soils. In addition, red and green seaweed contain up to 30% DM of protein. This represent a source of short/middle-term available nitrogen for the soil.

Green terrestrial plants are phylogenetically related to green seaweeds and red seaweed is an earlier common ancestor, so plants and seaweed still share large part of their metabolisms. The minerals, oligoelements, hormones and other bioactives in seaweed explains the large use of seaweed extracts in organo-mineral liquid fertilizers and in biostimulants for addressing abiotic stress (see figure 1).

Some sulphated oligosaccharides ligands present in seaweed are recognized by terrestrial plants as an elicitor of plant defences mechanisms. These properties are used for crop stimulation against biotic stresses including fungal and viral pathogens.

Regarding organo-mineral soil biostimulants, we have demonstrated that seaweed contributes to a boost in the plant root mycorrhization process and provides a starter effect when used in organo-mineral localized fertilizers applied upon sowing. Thanks to seaweed, organo-mineral fertilizer enhances the plant-microorganism partnership and the effects is independent of fertilizer type (see figure 2). In GEP experiments the positive impact of seaweed with fertilizers such as DAP, dolomite or potassium sulphate (see figure 3) is linked to mycorrhization and this improvement is robust, present in several soil systems as well as several maize crop varieties. ■

Figure 3. Corn roots mycorhization at 60 days (M%) - Mean value of 4 field GEP trials with same protocole. Seadry Organic Matter biostimulant improves mycorhization compared to Mineral Fertilizers alone (Dolomite, DAP, SOP). Pvalue = 0,003