Agroecological significance of ekofertile™ plant biostimulant on tropical soils and crop improvement

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Abstract

The environmentally degrading effects of synthetic chemical fertilizers have triggered the search for sustainable alternatives to resolve the global food crisis exacerbated by Covid-19. This has led to the development of biostimulants from plants, animals, or organic mineral salts. Biostimulants from these sources enhance plant growth through benefit nutrient uptake, nutrient use efficiency, tolerance to abiotic stress, pest and disease suppression, or crop quality and yield. Scientific research to produce and validate biostimulants from these sources is increasing in scope and number. ekofertile™ plant biostimulant produced from coal is capable of all biostimulant functions defined by the European Union on fertilizers aside from being environmentally friendly. ekofertile™ plant biostimulant from sand is rich in mineral nutrients and beneficial microorganisms. While biostimulants perform their role efficiently, their potential is limited to agroecological locations, edaphic factors, and crop types, as revealed by the literature. Tropical soils, considered one of the oldest soils, have organic matter within a few centimeters of the topsoil, making them variable, highly productive, and poor at the same time, needing inputs mostly from none agroecological-friendly sources like synthetic chemical fertilizers. Understanding the relationship among biostimulants, agroecological locations, edaphic factors, and crop types could be exploited to improve agricultural plant production. Thus, the current study was carried out to examine the agroecological significance of ekofertile™ plant biostimulant on tropical soils and crop improvement.

Keywords: Beneficial microbes, Eco-friendly, Mineral nutrients, Organic acids.

Introduction

With the advent of Covid-19, coupled with climate change and the ever-increasing human population, agriculture is facing a dilemma in sustaining the world food demand with more than 1 billion people without a guarantee for food security (Workie et al., 2020; Ben Hassen & El Bilali, 2022). This situation is the worst in tropical and subtropical locations, constituting 60 % of people without food security (Moroda et al., 2018). This is because the soils are acidic, where phosphorus, potassium, and some trace elements are highly immobile. The soils are also low in cation exchange capacity and experience higher temperatures and heavy rainfall leading to a greater rate of nutrient leaching (Stocking, 2003; Markgraf, 2011). Although tropical soils are very productive, they are variable and destitute in nutrients.

To cut this food crisis in the tropics, food importation and the use of agro-industrial fertilizers and pesticides of synthetic origin have been instrumental (Reveles, 2017; Mabhaudhi et al., 2018). While Covid-19 has compounded the situation, the aftermath of agro-industrial chemicals has left devastating consequences for the environment and human health (Stephens et al., 2020; Agbor et al., 2022a). These are soil degradation, biodiversity loss, climate change enhancement, eutrophication, food poisoning, heavy metals contamination, and cancer (Biswas et al., 2018). This has led to the global motion for holistic, sustainable agricultural inputs (Khadse et al., 2018; Agbor et al., 2022b).

Biostimulants have been at the forefront of this evolution because they are natural, come from plants, microbes, or inorganic salts, and are environmentally friendly (Bhupenchandra et al., 2020; Rouphael et al., 2020). The European Regulation on fertilizers defines biostimulants to have the following functions: benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, or crop quality and yield (Woo & Pepe, 2018; Caradonia et al., 2019; Ricci et al.,2019). Thus, the current study explores the significance of ekofertile™ plant biostimulants on acidic nutrients limiting tropical soils in boosting soil fertility and crop production.

Overview of Tropical Soils

The significant area occupied by tropical soils is in west Africa. Their formation is mainly bioclimatic, while the types and quality depend on the parent material, making them variable, highly productive, and poor at the same time for each climatic type (Lebel et al., 2009; Daniel et al., 2013; Moroda et al., 2018; Hounkpatin et al., 2022).

There are three major tropical soils sub-desert soils, ferralitic soils, and ferruginous tropical soils (Silva et al., 2020). The sub-desert soils lack organic materials, are shallow, and are generally well-provided with nutrients. They consist of sand and peddles that are thin and stony. Ferruginous soils cover a chunk of west Africa, and they are red or yellow. They are heavily weathered and protected from erosion by the dense forest vegetation. The yellow soil is rich in goethite and gibbsite-hydrated minerals, while the red soil consists of less hydrated or dehydrated hematite and kaolinite (Mancini et al., 2019). The soils are deep, old, and impoverished chemically, and the rich organic matter at the topsoil is only a few centimeters thick (Silva et al., 2018). Replenishment of organic matter is depleted rapidly due to the high rate of decomposition by microorganisms (Singh et al., 2020).

Areas with 250–600 mm/year of rainfall are alkaline and slightly acidic when heavily leached and are associated with ferruginous soils, same with dark brown or black vertisols that are easily flooded (Giresse, 2007). The best tropical soils are young, poorly evolved, deep loam soils derived from basalt and other tertiary volcanics and include hydrated minerals. They are well-drained and liable to gullies' erosion.

Generally, tropical soils are formed under hot conditions and experience hefty rainfalls (Ramankutty et al., 2002). They are the world's oldest soils, with little organic matter and nutrients (Martius, 2001). Tropical soils are ultisols that are reddish, clay-rich acidic soils, they are oxisols that are extensively leached, and the clay-size particles are dominated by oxides of iron and aluminum, which are low in natural fertility (Ca^{2+}, Mg^{2+}, $K+$) and high in soil acidity (H^{+}, Al^{3+}) (Fageria and Baligar, 2008; Shibata et al., 2017).

Overview of the Ekolive

Ekolive is the first and leading provider of an EU/ETV-certified eco-innovative bioleaching method (InnoBioTech®) for processing waste/minerals/soil using bacteria. This allows new raw material resources to be explored or gives various industrial wastes a second life, replacing dangerous mining and processing methods, and environmental hazards to sustainable eliminated.

Ekolive is ecological, innovative, and value-adding; the breadth and contribution of its innovative technology to achieving global sustainability goals are exceptional

In addition to biological soil remediation (cleaning of pollution – including pesticides) with bacteria, ekolive produces highly effective biostimulants that are listed on the input list for organic production (FiBL Netherlands). These complex and therefore unique biostimulants consist of plant growth-promoting bacteria, various effective organic acids and dissolved minerals and are currently produced at five locations in Europe using an EU-certified bioleaching process. They are basically environmentally friendly, ecologically sustainable, and serve in general:

• increasing the efficiency and yield of classic fertilizers by improving nutrient uptake and nutrient utilization by the plants,
• the improvement of all quality characteristics of the plants,
• faster germination, development and acceleration of growth – above all by promoting root growth and thus enlarging the root surface,
• increasing the germination rate and the yield (by 30 – 40 %), thus securing the yield,
• increasing the immunity of plants against pathogens,
• the increase in the nutrient and sugar content of the plants (by up to 150 %),
• increasing the plants´ resistance to abiotic stresses – such as drought, heat and cold.

Chemical, biological and organic acid constituents of ekofertile™ plant biostimulant

Table 1a. Chemical and microbial constituents of ekofertile™ plant biostimulant

Chemical content			Microbial content	
Constituent	Unit	Quantity	Genus	Species
Dry matter	%	0.91	Lactobacillus	Lactobacillus satsumensis
Organic matter	%	0.27		Lactobacillus diolivorans
Ash	%	0.53		Anaeromassilibacillus senegalensis
Total Nitrogen	%	0.04		Lactobacillus bifermentans
NH_4^+	%	0.01		Lactobacillus perolens
NO_3^-	%	< 0.01		Lactobacillus nagelii
Nitrogen	%	0.01	Clostridium_IV	Clostridium tyrobutyricum
Carbamide N	%	< 0.05		Clostridium ljungdahlii
P_2O_5 min. acid sol.	%	< 0.01	Clostridium_sensu_stricto	
K_2O	%	0.08		
Total MgO	%	0.03	Bifidobacterium	Bifidobacterium mongoliense
Total CaO	%	0.09		
Total Sulphur	%	0.03	Leuconostoc	Leuconostoc fallax
Sodium	%	0.09		
Silicon	%	< 0.01	Acetobacter	Acetobacter indonesiensis
Alkaline active comp.	%	0.44	Macellibacteroides	Macellibacteroides fermentans
Boron	mg/kg	< 2.00		
Cobalt	mg/kg	0.12	Bacteroides	Bacteroides luti
Iron	mg/kg	142		
Copper	mg/kg	< 2.00		
Manganese	mg/kg	6.58		
Molybdenum	mg/kg	< 0.10		
Zinc	mg/kg	< 2.00		
pH		4.50		
Salt content	% KCl	0.78		

Table 1b. Organic acid constituent of ekofertile™ plant biostimulant

Sample	Formic acid (mg/l)	Lactic acid (mg/l)	Acetic acid (mg/l)	Propionic acid(mg/l)	Butyric acid (mg/l)	Methanol (mg/l)	Ethanol (mg/l)
Organic acid	<5	9320	1550	19*	900*	8.6**	610

*HS-GC-MS measurement with internal standard calibration (4-methyl valeric acid)
**HS-GC-MS measurement with external standard calibration

Role of beneficial microbes found in ekofertile™ plant biostimulant

Table 2. Role of beneficial microbes found in ekofertile™ plant biostimulant

Genus	Coal Species	Function
Lactobacillus	Lactobacillus satsumensis	catalyzes the hydrolytic depolymerization of polysaccharides in soil. Breakdown of complex polysaccharides, including starch, to a readily available form of glucose, extracellular polymeric substances secretion & Fermentation (Adegboye et al., 2021)
	Lactobacillus diolivorans	Solubilize insoluble inorganic phosphate (Divjot et al., 2021)
	Anaeromassilibacillus Senegalensis Lactobacillus bifermentans Lactobacillus perolens Lactobacillus nagelii	
Clostridium_IV	Clostridium tyrobutyricum	Free Nitrogen fixation release polysaccharides and carboxylic acids like tartaric acid and citric acid to solubilize K, breakdown organic matter releasing citric acid, formic acid, malic acid, and oxalic acid making K available, fermentation (Figueiredo et al., 2020)
	Clostridium ljungdahlii	obligatory anaerobic heterotrophs only capable of fixing N2 in the complete absence of oxygen, isolated from rice fields (Figueiredo et al., 2020)
Clostridium_sensu_stricto		Fermentation (Figueiredo et al., 2020)

Bifidobacterium	Bifidobacterium mongoliense	degradation of non-digestible carbohydrates, protection against pathogens, production of vitamin B, antioxidants, and conjugated linoleic acids, and immune system stimulation (Zhang et al., 2019).
Leuconostoc	Leuconostoc fallax	catalyzes the hydrolytic depolymerization of polysaccharides in soil. Breakdown of complex polysaccharides, including starch, to a readily available form of glucose, fermentation
Macellibacteroides	Macellibacteroides fermentans	Fermentation (Jabari et al., 2012)
Bacteroides	Bacteroides luti	Pathogen-suppressing, contribute prominently to rhizosphere phosphorus mobilization, express constitutive phosphatase activity, and organic matter degradation (Lidbury et al., 2021)

The significance of ekofertile™ plant biostimulant on tropical soils and crop improvement

The significance of ekofertile™ plant biostimulant on tropical soils

- Supply of primary macronutrients (NPK), exchangeable cations (Ca, Mg, K, Na), micronutrients (Co, Fe, Mn), ekofertile™ plant biostimulant is also rich in salt, Sulphur, silicon, and organic matter (Table 1a). This will augment the variable highly productive and poor soils, ensuring continuous productivity and replenishment of the lost organic matter.
- The ekofertile™ plant biostimulant has an acidic pH of 4.5, which when mixed with water becomes neutral coupled with the alkaline active component (Table 1a), will buffer the acidic tropical soil pH to levels that permit an optimum uptake of nutrients, thus preventing the possibility of iron or aluminum toxicity due to acidic pH that permits their excess availability.
- Ekofertile™ plant biostimulant is endowed with beneficial microorganisms (Table 1a and Table 2) involved in free nitrogen fixation, phosphorus and potassium solubilization, organic matter degradation, organic acid production (Table 1b), vitamins, and enzyme activities that enrich the soil, making it fertile, thus nutrient turnover and soil formation.
- Owning to the fact that ekofertile™ plant biostimulant comes from natural sources, there will be no soil and environmental degradation, rather there will be improved the agroecological diversity of soil life.

The significance of ekofertile™ plant biostimulant on crop improvement

- Nutrients from ekofertile™ plant biostimulant and beneficial microorganisms (Table 1a, b, Table 2) provided in the soil will enhance crop growth and development.
- Beneficial microbes from ekofertile™ plant biostimulant exhibit pathogen suppression ability, preventing the plants from being devoured by pests.
- The high mineral content of the ekofertile™ plant biostimulant will boost the nutritional constituent of the crops grown with it, thus providing more nutritional food to the increasing population.

Conclusion.

Ekofertile™ plant biostimulant thus have tremendous agroecological beneficial potentials to tropical soils while ensuring sustainability and carrying out research to ascertain these literature potentials will be perfect.

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