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Invention of Organic Nanofertilizer and Its Use in Crop Production and Soil Recovery

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Abstract: Aerobic liquid organic nanofertilizer corresponds to the generation of our own knowledge, within the framework of the "Living Soil Paradigm", and arises as an alternative to the global climate crisis, which at the present time is no longer a technical, ideological or political problem, but a question of survival; this serious situation forces the change of life patterns and current scientific approaches, in the case of agriculture to value processes based on knowledge rather than conventional inputs. The initial findings of the aerobic liquid organic fertilizer NAOLA verify that it contains phytohormones, some still unknown, vitamins, antibiotics, enzymes, available nutrients, nanobacteria and other compounds, which as a foliar nutritional supplement for plants, improve their growth in organically fertilized soils, and also as irrigation revitalize the "living soil"; it is quite versatile in its use as foliar fertilizer, bio-irrigation, biohydroponics, bio-burners and bioremediation of contaminated soils. It is part of an agricultural sustainability strategy that makes quality organic fertilizers the main basis for the resilience of soils and plants in the face of the global climate crisis.

Key words: organic nanofertilizers, high Andean composting, biohydroponics

1. Introduction

NAOLA, an aerobic liquid organic nanofertilizer, is the generation of our own knowledge within the framework and coverage of the "Living Soil Paradigm"; its use in current peasant agriculture leads us to ask the following questions: What makes NAOLA improve plant growth in a difficult and harsh geographical environment? What does NAOLA have that is capable of improving and bioremediating contaminated soils? The answers to these questions are complicated, in the face of a global hegemonic capitalist agrarian and economic model, the indiscriminate use of agrotoxins, the interests of agro-exportation, the severe effects of climate change, regional wars and global pandemics. Scientific analysis and confrontation offer the possibility of finding answers, especially when after the Covid-19 pandemic, humanity is eagerly looking for organic foods to improve its immune defenses.

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2. Reference Framework

Origin of Aerobic Liquid Organic Fertilizer (AOLA): the organic nanofertilizer AOLA was created in 2014 by researchers Chilon E. & Chilon J. (2015) [1], through an innovative process of natural microbial nanobiotechnology, under oxygenation, using high Andean compost and other organic fertilizers as substrates; they experimentally tested AOLA in several agricultural campaigns, and in various forms of use, such as foliar fertilizer in vegetables, bioirrigation in soils, biohydroponics with green fodder and vegetables and in bioremediation of soils contaminated with hydrocarbons, verifying its positive effects on the growth and development of plants and soil improvement. Based on the first positive results and to comply with the rigor of conventional science, they promoted a series of research and thesis and dissertation studies. AOLA is part of the "Living Soil" paradigm and is part of the strategies for sustainable agriculture, the recovery and preservation of

agricultural soils and the survival and perpetuation of the human species [2].

High Andean Compost as a base substrate for AOLA: High Andean compost has its origins in the recovery of the ancient knowledge of the Andean and Mesoamerican ancestral peoples, who bequeathed us traditional biotechnology aimed at the care and nourishment of "living soil" with high-quality organic fertilizers made with local ferments or "chicha" of Andean grains [3], favoring the composting process, demonstrating that it is possible to advance as societies, to the extent that we simultaneously go back to the origin, and then project ourselves into the future [4]. High Andean compost provides organic matter, beneficial microorganisms, biosynthesized substances and available mineral nutrients, which make compost the basis of a "living soil" that is resilient to climate change [5].

3. Materials and Methods

3.1 Location of the Experimental Area

The field study was carried out at the Experimental Campus of Agronomy of the Universidad Mayor de San Andrés, the Tiwanaku Peasant Academic Unit-Bolivian Catholic University, and the last stage at the Soil Biofertility Center of the Agronomy Degree of the Bolivian Aymara Indigenous University Tupak Katari, located in the Cuyahuani Native Community, Huarina Municipality, Omasuyos Province, Department of La Paz-Bolivia; at the coordinates 16°13′10.95″ LS and 68°34′50.64″ LO, at an altitude of 3848 meters above sea level. The research began in 2015 and continued until 2020, being interrupted by the COVID-19 pandemic and resumed in 2021 and 2022.

Study method: Synergistic method of local knowledge/scientific knowledge [6], and comparative method, which integrates qualitative paradigms of an explanatory nature, and the quantitative one with observable phenomena, susceptible to measurement, selection of types of organic substrates, types of NAOLA.

3.2 Methodological Procedure

- Preparation and selection of organic base substrates: the method of preparation of organic substrates and determination of their quality is described in detail in detail in heuristics of high Andean composting [7].
- Preparation of aerobic liquid organic nanofertilizer (NAOLA): the aerobic liquid organic nanofertilizer was prepared based on the method of Chilon E. & Chilon J. (2015) [1], but improved and adjusted by the same authors, achieving greater purity. The natural nanobiotechnological method provides the appropriate conditions for beneficial microorganisms.
- Determination of technical dose of NAOLA by type of plant and soil: corresponds to the most delicate and complicated phase; experimentally, AOLA at 100% purity is very strong, requiring its dilution with treated water in doses according to the crop, soil and use modalities.

4. Results and Discussion

After publishing the first work, the authors of NAOLA [1] along with their collaborators and students have produced several works that have transformed the study of NAOLA into a rigorously experimental science, and the results are as follows.

4.1 Effect of AOLA as Foliar Nutrition in Plants Grown in Fertilized Soils

Table 1 shows that the first AOLA research (2014) established that the 20% AOLA dose had a beneficial effect on chard, spinach and parsley vegetables, resulting in greater leaf biomass and greater plant height, but in lettuce the 10% AOLA dose had the best results, observing that at higher doses the lettuce had a noticeable elongation and stress; it was also verified that 100% pure AOLA affects plants with drying and necrosis [8]. In quirquiña (Porophyllum ruderale), the 20% AOLA level had the highest fresh weight with

10.24 g/plant, and the highest plant height with 21.83 cm [9]. In cucumber (Cucumis sativus), 10% AOLA had the highest fruit weight with 182.72 g/unit [8]. In kale (Brasica oleraceae), 20% AOLA gave the highest yield in the Dwarf Siverian variety with 247.3 g/plant; with the 30% AOLA dose, it was the Dwarf Siverian variety with 222.7 g/plant [10]. In spinach (Spinacea oleracea L.) 20% AOLA provided the highest yield with 48.11 gr/plant [11]. Another trial in spinach found the highest yields for the sowing density 30 cm/plant x 30 cm/furrow with 30% AOLA [12]. In stevia (Stevia rebaudiana Bert.), 30% AOLA had the highest number of leaves per plant (240 leaves) and the highest dry matter with 6.42 gr/plant [13]. In coffee seedlings (Coffea arabiga), the Catuai variety responded better to 10% AOLA, the Castilla variety to 20% AOLA [14]. In coca (Erythroxylum coca L.), 10% AOLA had the highest green matter yield (930 kg green matter/ha), in dry matter (390 kg/ha) it was 30% AOLA [15]. In forage oats (Avena sativa L.) associated with vetch (Vicia villosa Roth), 30% AOLA had the highest green and dry yields [16]. In celery (Apium graveolens L.), 30% AOLA showed the highest plant height with 44.35 cm, and the highest green weight with 245.63 grams/plant [17]. Another experiment in celery found that 20% AOLA gave the best yields in green weight in two successive harvests [18]. It is concluded that AOLA, as a foliar supplement for plants grown in organically fertilized soils, guarantees their adequate growth.

4.2 Production of Biohydroponic Green Fodder in Trays With AOLA

Table 2 presents some experimental results of biohydroponic green fodder (BGF) production; in the case of oats (Avena sativa), with 30% AOLA the Gaviota variety had a greater plant height (16.91 cm/p) and greater green weight (2.65 kg/0.25 m^2) [19]. In barley (Hordeum vulgare L.), 30% AOLA had a better effect with the IBTA 80 variety and 20% AOLA with the criolla variety [20]. In hairy vetch (Vicia velluda), 30% AOLA had the best effect on the dasycarpa and roth varieties [21]. In triticale (Triticum secale), 30% AOLA presented the highest values in plant height (16.6 cm/p), and green matter with 878.67 g [22]. Biohydroponics of green fodder with AOLA establishes that its effect depends on the type and variety of cereals, and that the recommended levels are between 20% and 30% AOLA and that this level should not be exceeded.

4.3 Biohydroponics of Floating Root Vegetables With AOLA

Table 3 shows that in watercress (Nasturtiom officinali) collected from the surroundings of Lake Titicaca, and in spinach (Spinacea oleracea L.), the 10% AOLA dose presented the highest values of height and green yield [23]; in lettuce (Lactuca sativa), butterhead variety, the 10% AOLA level gave the best yield [24], verifying that higher doses of AOLA generate elongation and deformation of lettuce; In the case of chard (Beta vulgaris L. var. Cicla. L) under floating root biohydroponics, its green mass production was much lower, compared to its traditional cultivation in the soil [6], being recommended the cultivation of chard in soil fertilized with compost, supplemented with foliar nutrition at 20% AOLA. Other crops are being subject to further studies.

4.4 AOLA Effect as Bioirrigation on Crop Yield

Table 4 shows the effect of AOLA as bioirrigation in the case of broccoli (Brassica oleracea) variety Di Cicco, the 20% AOLA dose, led to a greater plant height with 84.6 cm, and a higher yield in head weight per plant (19,047 kg/ha), in addition, AOLA regulated soil salinity [25]. In potato crops (Solanum tuberosum) variety Waicha, with bioirrigation complementary to rainfall, the 30% AOLA dose presented the highest yield with 24,514.28 kg tubers/ha [5], improving the crop affected by frost.

4.5 AOLA and in Vitro Cultivation in Petri Dishes

An interesting result of the research with AOLA was to verify its role and effect as a cultivation medium in the in vitro multiplication of microorganisms in Petri dishes. Loza E. (2021) [26] tested three biological culture media, potato extract and AOLA, finding that the AOLA substrate at a dose of 40% presented the best results in the multiplication of *Rhizobium sp*, with greater longitudinal growth and a greater expansion surface, concluding that the best organic substrate was AOLA.

4.6 Characteristics and Chemical Composition of AOLA

The new generation of AOLA showed the same trend as reported by Chilon & Chilon (2015) [1], with a high variation in its nitrogen, phosphorus and potassium contents; a pH between the ranges of 6.19 (slightly acidic) to 8.79 (strongly alkaline) and an electrical conductivity of 1422 µS/cm (non-saline) to 4222 µS/cm (moderately saline); the analyses of heavy elements indicate very low contents and only traces, ruling out risks of affecting the soil and the plant. Conventional chemical analyses report very low and scarce amounts of N, P, K in AOLA, disqualifying this and other organic fertilizers. Conventional laboratory methods often present serious limitations, considering AOLA and compost as inert bodies, so they tell us little or almost nothing about their biological characteristics. In addition, the beneficial effect of AOLA on crop growth and development and soil fertility is verified in field conditions.

4.7 Bioindicators of AOLA Quality and Its Potential in the Face of Climate Change

This is a field of research that is still in its infancy, but there are significant advances that are becoming more important compared to conventional laboratory methods that have serious limitations. The Pfeiffer chromatographic evaluation technique [27] is used, as well as the evaluation and characterization of colonies of microorganisms collected "in situ" with optical microscopy. The characteristics and composition of AOLA, in phytohormones, vitamins, antibiotics, enzymes, mucilaginous substances, available nutrients, nanobacteria, and other substances still unknown, have a favorable impact on the resilience of the soil microbiota and plants in the face of global climate change.

5. Conclusions and Recommendations

Liquid aerobic organic nanofertilizer corresponds to the generation of our own knowledge, within the framework and coverage of the "Living Soil Paradigm" and emerges as an alternative to the global climate crisis, which at the present time is no longer a technical, ideological or political problem, but a question of survival. The beneficial effects of AOLA on plants and on soil fertility were verified with doses of 10%, 20% and 30% AOLA, but its application in pure state causes stress and necrosis in the leaves. To guarantee its quality and efficiency, AOLA must be produced in a laboratory with control of all internal and external factors, and its quality control, to then be released for use by agricultural producers. In addition, technical support and training on the appropriate doses of AOLA are required, according to the type of plant and soil.

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