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Bio stimulation activity of minerals obtained from an innovative seawater extraction process in the cultivation of vegetable plants

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Abstract

Research objective: This research work aimed to evaluate the stimulating potential of a product (FertilTomix) obtained by an innovative process of extraction from seawater on seeded plants of *Cichorium intybus* and *Carthamus tinctorius*. Furthermore, it was assessed whether there are differences in the product's potential based on the different types of extraction (lye, soda, soda+silver) and whether there are beneficial interactions with the micro- and mesofauna of the cultivation substrate, with direct and indirect effects on plant mortality.

Materials and Methods: The experiments, started in August 2022, were conducted in the greenhouses of CREA-OF in Pescia (Pt), Tuscany, Italy. On October 28, 2022, plant height, leaves number, leaves surface area, vegetative weight, roots volume and length, the number of germinated seeds, average germination time, the number of microorganisms in the substrate, plants dead number and pH were determined. In addition, the SPAD index was measured on three leaves pinched from the bottom to the apex of the canopy of each plant (for a total of 90 measurements per treatment) and tissue mineral content was evaluated on collected dry matter (N, P, K, Ca, Mg, Fe and Na).

Results and Discussion: The experiment showed that using FertilTomix, regardless of the mineral extraction process from the sea it contains, can significantly increase seed germination, vegetative and root growth, root length and reduce plant mortality in *Cichorium intybus* and *Carthamus tinctorius*. A fascinating aspect noted in the treated theses was also the significant increase in microbial biomass, which certainly had a decisive effect on the development of the seeded seedlings and the reduction in mortality. In this respect, a significant increase in the mineral content in the vegetative tissues of plants treated with FertilTomix was evident. The biostimulant based on Ecklonia maxima also showed significant improvements in all agronomic and microbial parameters analyzed compared to the control but less than the treatment with the sea mineral extracts.

Conclusions: The results obtained are particularly interesting for people who have to cultivate in arid environments or without drinking water, as well as those who want to start reducing the use of fertilizers of industrial origin. New experiments are currently underway to evaluate the recycled water obtained from the process of extracting minerals from the sea and assess whether it can be used in agriculture.

Keywords: Seawater minerals; Microorganisms; Sustainable agriculture; Bio fertilizers; Rhizosphere

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1. Introduction

Scientists generally see the sea as the locale of the origin of life on Earth. Life, as we know it today, could not exist without the sea. The functions of the sea concerning earthly life are numerous. First, it acts as a great thermostat and heat reservoir, levelling out the temperature extremes which would prevail over the Earth without its moderating influences [1]. The sea provides a means for the least expensive form of transportation known to man. Finally, as a source of minerals, the sea has been exploited little relative to its potential [2]. The primary reasons for this default are a lack of knowledge concerning what is in the ocean and of advantages of exploiting marine mineral deposits, the absence of a technology to exploit the deposits economically, and no pressing need, either economically or politically, to exploit them at present [3]. Regarding mineral resources, the sea can be divided into five regions: marine beaches, seawater, continental shelves, surficial sediments, and the hard rock beneath the surficial seafloor sediments. Various minerals are presently being extracted from the first three regions of the ocean. As a result, rather voluminous literature exists on what is being recovered and the methods used to recover them. In the open ocean, biotic processes probably dominate in separating and concentrating the various elements which enter the sea. Both plants and animals play significant roles in these processes [4]. For example, plants and animals extract large amounts of calcium and silicon from seawater for use in forming shells and skeletons [5]. Other elements, such as copper, may be concentrated by animals for use in their metabolic processes. In addition, biota such as manganese or by consuming the organic parts of complexes by which such elements are held in solution [6]. The carried elements may then be deposited and concentrated in the body of the animal or may convert to an insoluble precipitate and be released to diffuse through the seawater, slowly settling on the sea floor. After the death of the animal or plant and the dissolution of the biogenous material, the residue, after diagenetic changes, can be classified as inorganic for purposes of consideration as economic mineral deposits [7].

1.1. Minerals from seawater

If whoever named the planet were aware of the true nature of its surface, they would probably have given it some name denoting water rather than Earth. Almost 71% of the Earth's surface is water. Covering an area of 139 million square miles at a mean depth of 2.46 miles, the sea holds about 330 million cubic miles of water. Sea water contains an average of 3.5% of various elements in solution; thus, each cubic mile of seawater, weighing some 4.7 billion tons, holds about 166 million tons of solids [8]. The oceans are a storehouse of some 5.10^{16} tons of mineral matter. Given sophisticated analytical procedures, probably every known, naturally occurring element could be found in seawater [9]. The concentration of some 60 elements in seawater has been measured. Table 1 lists these elements, their concentration, the amount of the elements in one cubic mile of sea water and the total amount in the world's oceans. Other elements, such as ytterbium, beryllium, zirconium, platinum etc., can be inferred to be part of seawater because of their appearance in authigenic minerals of the sea floor in marine organisms [10]. Biological activity at the ocean surface can significantly change the concentrations of various elements from place to place and from time to time [11]. It is never safe to assume that seawater is a homogeneous medium where the concentration of the less abundant elements is concerned. It has been known for some time that marine organisms can affect concentrations of certain elements in their bodies many times over the concentrations of these elements in seawater [12]. Vanadium, for example, is taken up by the mucus of certain tunicates and can be concentrated in these animals by a factor of over 280.000 times the concentration of that element in seawater. Other marine organisms can affect a concentration of copper and zinc by a factor of about one million. Fish concentrate lead by a factor of 20 million in parts of their skeletons. However, the mechanism by which these organisms can concentrate on the elements is essential. Understanding these processes might lead to an imitative but artificial method of extracting and concentrating elements from dilute solutions [13].

1.2. Experiments with minerals extracted from the sea

Professor Hou Tian Zhen, head of the Department of Tree Physiology and Biochemistry at the Xinjiang Academy of Forestry Sciences in the People's Republic of China, led a team of researchers evaluating the use of sea minerals in three separate experiments [14]. In 1989, in the first experiment conducted in the greenhouse of the A-ning Experiment Station, tomatoes treated with these minerals had an average of almost twice as many flowers per plant and 27% more fruit [15]. In 1990, a field experiment at the A-ning Experiment Station showed that treated green beans increased yields by 81%, sweet beet yields by 67% and soybean yields by 29%. In 1991, a large-scale experiment was conducted using watermelon plots 300 metres apart in a field at the A-ning Experiment Station [16]. The treated melons produced 65% more than the control group. Harold Aungst, an alfalfa grower from Pennsylvania who used the extract with minerals from the sea, showed a 29% increase in protein, with a significant increase in yield per acre and five cuts instead of three. The first year yielded 7.6 tonnes per acre, almost double the state average of 3.4 tonnes per acre. The second year increased to 10 tonnes/acre, three times the state average [17]. The use of treated hay also resulted in a 30% increase in milk production. Wilson Mills of the Circle K Apple Orchard in Wisconsin, which has used a sea extract since 1989, achieved an increase in fruit production on apple trees. Analyses showed a 1200% increase in nutritional absorption of zinc, 400% in iron, 326% in chromium and 120% in potassium. The apples were giant and ripened 2 to 3 weeks earlier [18]. For the first eight years, it doubled the yield each year, tripled the usual fruit set and had a significantly higher sugar content. A banana plantation in Okinawa experienced a 100% increase in yield and a 35% reduction in ripening time. In 1990, a field experiment at the A-ning Experiment Station showed that treated green beans increased yield by 81% and treated sweet beets increased by 67%. Treatment with marine mineral extracts increased coffee production by 50-100%, with better flavour, more giant beans and 80% Fancy or Gourmet quality when environmental stress caused 80% empty pods on other neighbouring farms. Young plants yielded 1/3 earlier than expected, and the crop ripened more evenly, so fewer harvests were needed [19,20, 21].

Table 1 Concentration and amounts of 60 of the elements in seawater

Element	Concentra-tion (mg/l)	Amount of element in seawater (tons/mile^3)	The total amount in the oceans (tons)	Element	Concentra-tion (mg/l)	Amount of element in seawater (tons/mile^3)	The total amount in the oceans (tons)
Chlorine	19.000,0	89,5 x 10^6	29,3 x 10^{15}	Manganese	0.002	9	3 x 10^9
Sodium	10.500,0	49,5 x 10^6	16,3 x 10^{15}	Titanium	0.001	5	1.5 x 10^9
Magnesium	1.350,0	6,4 x 10^6	2,1 x 10^{15}	Antimony	0.0005	2	0.8 x 10^9
Sulphur	885.0	4,2 x 10^6	1,4 x 10^{15}	Cobalt	0.0005	2	0.8 x 10^9
Calcium	400.0	1,9 x 10^6	0,6 x 10^{15}	Caesium	0.0005	2	0.8 x 10^9
Potassium	380.0	1,8 x 10^6	0,6 x 10^{15}	Cerium	0.0004	2	0.6 x 10^9
Bromine	65.0	306.000	0,1 x 10^{15}	Yttrium	0.0003	1	5 x 10^8
Carbon	28.0	132.000	0,04 x 10^{15}	Silver	0.0003	1	5 x 10^8
Strontium	8.0	38.000	12,000 x 10^9	Lanthanum	0.0003	1	5 x 10^8
Boron	4.6	23.000	7,100 x 10^9	Krypton	0.0003	1	5 x 10^8
Silicon	3.0	14.000	4,700 x 10^9	Neon	0.0001	0.5	150 x 10^6
Fluorine	1.3	6.100	2,000 x 10^9	Cadmium	0.0001	0.5	150 x 10^6
Argon	0.6	2.800	930 x 10^9	Tungsten	0.0001	0.5	150 x 10^6
Nitrogen	0.5	2.400	780 x 10^9	Xenon	0.0001	0.5	150 x 10^6
Lithium	0.17	800	260 x 10^9	Germanium	0.00007	0.3	110 x 10^6
Rubidium	0.12	570	190 x 10^9	Chromium	0.00005	0.2	78 x 10^6
Phosphorus	0.07	330	110 x 10^9	Thorium	0.00005	0.2	78 x 10^6
Iodine	0.06	280	93 x 10^9	Scandium	0.00004	0.2	62 x 10^6
Barium	0.03	140	47 x 10^9	Lead	0.00003	0.1	46 x 10^6
Indium	0.02	94	31 x 10^9	Mercury	0.00003	0.1	46 x 10^6
Zinc	0.01	47	16 x 10^9	Gallium	0.00003	0.1	46 x 10^6
Iron	0.01	47	16 x 10^9	Bismuth	0.00002	0.1	31 x 10^6
Aluminium	0.01	47	16 x 10^9	Niobium	0.00001	0.05	15 x 10^6
Molybdenum	0.01	47	16 x 10^9	Thallium	0.00001	0.05	15 x 10^6
Selenium	0.004	19	6 x 10^9	Helium	0.000005	0.03	8 x 10^6
Tin	0.003	14	5 x 10^9	Gold	0.000004	0.02	6 x 10^6
Copper	0.003	14	5 x 10^9	Protactinium	2 x 10^{-9}	1 x 10^{-5}	3,000
Arsenic	0.003	14	5 x 10^9	Radium	1 x 10^{-10}	5 x 10^{-7}	150
Uranium	0.003	14	5 x 10^9	Rodon	0.6 x 10^{-15}	3 x 10^{-12}	1 x 10^{-3}
Nickel	0.002	9	3 x 10^9				
Vanadium	0.002	9	3 x 10^9				

1.3. Research Objectives

This research aimed to evaluate the stimulating potential of a product (FertilTomix) obtained by an innovative process of extraction from seawater on seeded plants of *Cichorium intybus* and *Carthamus tinctorius* (Figure 1A-1B). Furthermore, it was assessed whether there are differences in the product's potential based on the different types of extraction (lye, soda, soda+silver) and whether there are beneficial interactions with the micro- and mesofauna of the cultivation substrate, with direct and indirect effects on plant mortality.

Figure 1 Detail of the treatment with FertilTomix on *Cichorium intybus* (A) and presence of earthworms in the theses treated with FertilTomix on *Carthamus tinctorius* (B)

2. Material and methods

The experiments, started in August 2022, were conducted in the greenhouses of CREA-OF in Pescia (Pt), Tuscany, Italy (43°54′N 10°41′E) on *Cichorium intybus* and *Carthamus tinctorius* (Figure 1A,1B). The seeds were placed in ø 10 cm pots, 30 seeds per thesis, divided into three replicas of 10 seeds each. The experimental groups were:

- Group control (CTRL) (peat 80%+ pumice 20%), irrigated with water and substrate fertilized one time per week with Compo BIO (organic fertilizer for vegetables; organic nitrogenous fertilizer; fluid borer), 5 ml of product in 1 L of water and then 3 ml per plant of this dilution;
- Group biofertilizer (BIOAL) (peat 80%+ pumice 20%), irrigated with water and substrate fertilized one time per week with Compo BIO (organic fertilizer for vegetables; organic nitrogenous fertilizer; fluid borer), 5 ml of product in 1 L of water and then 3 ml per plant of this dilution; In addition, an algae-based biofertilizer was used (Kelpak biostimulant, *Ecklonia maxima, Kelp products International),* dilution 1:1000, 3 ml of this dilution once a week;
- The group with FertilTomix with lye extraction procedure (FE0) (peat 80% + pumice 20%) irrigated with water, 3 ml per plant once a week;
- The group with FertilTomix with soda extraction procedure (FE1) (peat 80% + pumice 20%) irrigated with water, 3 ml per plant once a week;
- The group with FertilTomix with soda extraction procedure (FE2) with silver (peat 80% + pumice 20%) irrigated with water, 3 ml per plant once a week;

The plants were watered one time a day and grown for two months. Then, the plants were irrigated with drip irrigation. The irrigation was activated by a timer whose program was adjusted weekly according to climatic conditions and the leaching fraction. On October 28, 2022, plant height, leaves number, leaves surface area, vegetative weight, roots volume and length, the number of germinated seeds, average germination time, the number of microorganisms in the substrate, plants dead number and pH were determined. In addition, the SPAD index was measured on three leaves pinched from the bottom to the apex of the canopy of each plant (for a total of 90 measurements per treatment) and tissue mineral content was evaluated on collected dry matter (N, P, K, Ca, Mg, Fe and Na).

2.1. Analysis methods

- pH: For pH measurement, 1 kg of the substrate was taken from each plant, and 50 g of the mixture was placed in a beaker containing 100 ml of distilled water. After 2 hours, the water was filtered and analyzed [22];

- Microbial count: direct determination of total microbial count by microscopy of cells contained in a known sample volume using counting chambers (Thoma chamber). The surface of the slide is etched with a grid of squares, with the area of each square known. Determination of viable microbial load after serial decimal dilutions, spatula seeding (1 ml) and plate counting after incubation [23];
- Analytical instruments: IP67 PHmeter HI99 series - Hanna instruments; Combined test kit for soil analysis - HI3896 - Hanna instruments; Microbial diversity of culturable cells [13];
- Reduced N was determined through Kjeldahl distillation after dry matter digestion with sulphuric acid. Dry matter was then subjected to nitric-perchloric acid digestion to determine:
  - P content through the colourimetric method using a spectrophotometer;
  - K, Ca, Mg, Fe and Na content through atomic absorption spectrophotometry [24].

2.2. Statistics

The experiment was carried out in a randomized complete block design. Collected data were analyzed by one-way ANOVA, using GLM univariate procedure, to assess significant ($P \leq 0.05$, 0.01 and 0.001) differences among treatments. Mean values were then separated by LSD multiple-range tests ($P = 0.05$). Statistics and graphics were supported by the programs Costat (version 6.451) and Excel (Office 2010).

3. Results

The experiment showed that using FertilTomix, regardless of the mineral extraction process from the sea it contains, can significantly increase seed germination, vegetative and root growth, and root length and reduce plant mortality in *Cichorium intybus* and *Carthamus tinctorius* (Tables 2-4). An exciting aspect noted in the treated theses was also the significant increase in microbial biomass, which certainly had a decisive effect on the development of the seeded seedlings and the reduction in mortality (Tables 3-5). In this respect, a significant increase in the mineral content in the vegetative tissues of plants treated with FertilTomix was evident (Tables 6-7). The biostimulant based on *Ecklonia maxima* also showed significant improvements in all agronomic and microbial parameters analyzed compared to the control but less than the treatment with the sea mineral extracts.

In general, in the FertilTomix-treated theses (FE1 and FE2), minerals obtained from the soda and soda+silver extraction process proved to be better than the treatment based on the lye-based extraction process. The agronomic results on *Cichorium intybus* and *Carthamus tinctorius* of the FertilTomix treatments were almost comparable.

Table 2 Evaluation of the use of FertilTomix on the vegetative and root biomass of *Cichorium intybus*

Groups	Plant height (cm)	Leaves number (n°)	Leaves surface area (cm^2)	Vegetative Weight (g)	Roots Volume (cm^3)	Roots Length cm)
CTRL	7.45 e	4.40 d	36.29 e	40.29 e	24.47 e	7.75 e
BIOAL	8.82 d	6.20 c	40.60 d	41.75 d	25.15 d	8.16 d
FE0	10.30 c	8.00 b	42.93 c	42.60 c	26.83 c	9.72 c
FE1	12.42 b	8.40 b	43.97 b	43.60 b	27.58 b	11.28 b
FE2	12.74 a	9.40 a	45.53 a	44.46 a	28.02 a	12.94 a
ANOVA	***	***	***	***	***	***

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

The plants treated with (FE0, FE1, and FE2) showed a significant increase in plant height and the number of leaves was observed, with differences relating to the type of extraction process (Figures 2-3-4). There was also an increase in leaf area and root length; treatment with minerals extracted from the sea lengthened the roots on average by 2-3 cm. There were no significant differences in the pH of the substrate. However, the theses treated with FertilTomix showed a better chlorophyll content than the control and the treatment with fertilizing algae. In addition, the theses treated with sea extract showed better seed germination and a significant reduction in the average germination time.

Concerning the mineral content of the plant tissues of the vegetable species tested, the theses treated with sea minerals showed a significant increase in the N, P, K, Ca, Fe, and Na content in lettuce. At the same time, sodium alone was not significant for *Carthamus tinctorius* (Tables 6-7).

Table 3 Evaluation of the use of FertilTomix on seed germination and microbial biomass of *Cichorium intybus*

Groups	Germinated seed (n°)	Average germination time (days)	Substrate total bacteria (Log CFU/g soil)	pH substrate	Plants dead number (n°)
CTRL	23.80 e	5.20 a	2.27 c	6.83 b	1.20 a
BIOAL	26.20 d	5.20 a	3.56 b	6.84 b	0.20 b
FE0	27.40 c	5.20 a	4.71 a	6.90 a	0.20 b
FE1	28.60 b	4.20 b	4.78 a	6.82 b	0.00 b
FE2	29.60 a	4.00 b	4.85 a	6.78 c	0.00 b
ANOVA	***	***	***	***	***

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

Table 4 Evaluation of the use of FertilTomix on the vegetative and root biomass of *Carthamus tinctorius*

Groups	Plant height (cm)	Leaves number (n°)	Leaves surface area (cm^2)	Vegetative Weight (g)	Roots Volume (cm^3)	Roots Length (cm)
CTRL	9.81 e	4.80 d	28.51 e	27.44 e	19.77 e	6.67 e
BIOAL	10.76 d	6.20 c	29.38 d	29.72 d	20.15 d	7.20 d
FE0	11.36 c	8.00 b	30.32 c	30.26 c	21.40 c	8.27 c
FE1	12.85 b	9.40 a	31.73 b	31.63 b	22.71 b	9.17 b
FE2	13.61 a	9.80 a	32.59 a	33.21 a	23.25 a	9.84 a
ANOVA	***	***	***	***	***	***

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

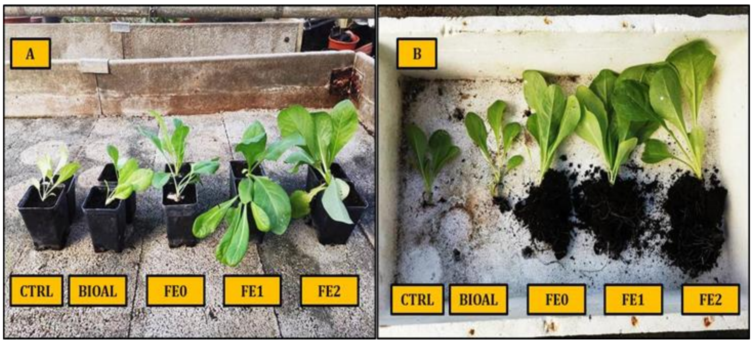

Figure 2 Comparison of the control thesis (CTRL), the one with algae biofertilizer (BIOAL) and all the theses treated with FertilTomix (FE0; FE1; FE2) on the vegetative (A) and roots (B) growth of *Cichorium intybus*

Table 5 Evaluation of the use of FertilTomix on seed germination and microbial biomass of *Carthamus tinctorius*

Groups	Germinated seed (n°)	Average germination time (days)	Substrate total bacteria (Log CFU/g soil)	pH substrate	Plants dead number (n°)
CTRL	22.20 d	11.00 a	2.38 e	6.83 b	1.24 a
BIOAL	24.40 c	9.80 b	3.18 d	6.84 b	0.21 b
FE0	26.20 b	9.20 bc	4.05 c	6.90 a	0.19 b
FE1	27.40 a	8.60 cd	4.23 b	6.83 b	0.00 b
FE2	27.80 a	8.40 d	4.44 a	6.78 c	0.00 b
ANOVA	***	***	***	***	***

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

Table 6 Spad analysis and Mineral content of vegetative tissues of *Cichorium intybus*

Groups	Spad	N (g/kg)	P(g/kg)	K(g/kg)	Ca(g/kg)	Mg(g/kg)	Fe(g/kg)	Na(g/kg)
CTRL	22.60 c	15.14 e	1.62 e	13.42 d	14.33 d	4.72 d	0.18 e	4.32 a
BIOAL	24.00 b	16.28 d	1.75 d	14.50 c	15.26 c	5.20 c	0.27 d	4.16 b
FE0	26.00 a	16.93 c	1.86 c	15.29 b	15.96 b	5.70 b	0.32 c	4.17 b
FE1	25.40 a	17.40 b	1.99 b	15.37 b	16.49 a	5.92 a	0.45 b	3.99 c
FE2	26.40 a	17.55 a	2.04 a	16.17 a	16.70 a	5.96 a	0.53 a	4.07 bc
ANOVA	***	***	***	***	***	***	***	**

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

Table 7 Spad analysis and Mineral content of vegetative tissues of *Carthamus tinctorius*

Groups	Spad	N (g/kg)	P(g/kg)	K(g/kg)	Ca(g/kg)	Mg(g/kg)	Fe(g/kg)	Na(g/kg)
CTRL	26.20 d	13.54 e	1.16 e	10.19 e	12.19 e	3.76 d	0.15 e	3.18 a
BIOAL	28.20 c	14.60 d	1.41 d	11.17 d	13.22 d	4.14 c	0.22 d	3.21 a
FE0	32.60 b	15.66 c	1.54 c	12.34 c	13.58 c	4.24 bc	0.34 c	3.13 a
FE1	35.80 a	16.16 b	1.65 b	13.03 b	14.36 b	4.32 b	0.41 b	3.12 a
FE2	36.80 a	16.89 a	1.73 a	13.22 a	14.67 a	4.92 a	0.47 a	3.13 a
ANOVA	***	***	***	***	***	***	***	Ns

One-way ANOVA; n.s. – non-significant; *,**,*** – significant at P ≤ 0.05, 0.01 and 0.001, respectively; different letters for the same element indicate significant differences according to Tukey's (HSD) multiple-range test (P = 0.05).Legend: (CTRL) control + COMPO BIO; (BIOAL) COMPO BIO + Ecklonia maxima ;(FE0) FertilTomix with lye extraction;(FE1) FertilTomix with soda extraction; (FE2) FertilTomix with soda extraction procedure with silver

Figure 3 Effect of FertilTomix treatment (lye extraction procedure; FE0) on root growth of *Cichorium intybus* compared to fertilizing algae treatment (BIOAL)

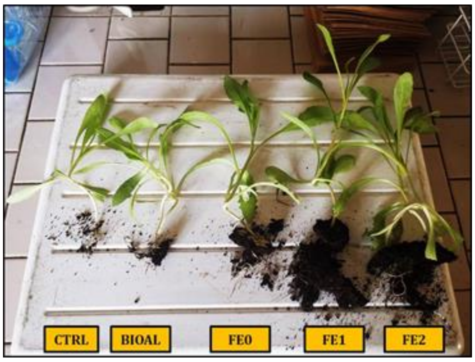

Figure 4 Comparison of the control thesis (CTRL), the one with algae biofertilizer (BIOAL) and all the theses treated with FertilTomix (FE0; FE1; FE2) on the vegetative (A) and roots (B) growth of *Carthamus tinctorius*

4. Discussion

Saltwater occupies 70 per cent of the globe's surface [25]. The seas and oceans are our planet's largest reservoirs of healing remedies. In seawater, all the elements of Mendeleev's periodic table have been found, as well as a great variety of molecules of an organic nature, such as amino acids, vitamins, fatty acids, polysaccharides, and enzymes [26,27,28]. The sea is more than a breeding ground: it is the vital element par excellence. Current knowledge of biochemistry still needs to be improved to conceive of all the therapeutic possibilities of seawater [29]. Much more than a source of minerals and trace elements, seawater proves to be an authentic modern ally [30]. Seawater is a complex solution, a 'mineral' water that contains virtually all known elements, from hydrogen to uranium, sometimes in considerable quantities, sometimes in minute doses (e.g. gold).

In water, salts dissociate into positive ions (cations) and negative ions (anions). Sodium chloride, NaCl, breaks down into Na+ and Cl-. Magnesium sulphate (MgSO4) becomes Mg++ and SO4--. Within the sixty or so salts counted in seawater, six (Na+, K+, Mg++, Ca++, Cl-, SO4--) account for more than 99% of the salt composition. The marine salts were mostly transported by run-off water that washed away the soil of the continents over millions of years [31]. Volatile elements (sulphur, nitrogen, boron, etc.) come from the primordial atmosphere. Other minerals come from hot submarine hydrothermal springs [32].

Water from the cold seas penetrated the oceanic Earth's crust, which was subjected to great pressure and very high temperatures in crossing. Thus, it dissolved many elements, which it poured into the underwater source. One of the significant peculiarities of seawater is that it has a constant composition: whatever the degree of salinity, the relative proportions of its main components remain unchanged [33,34]. The great activity of seawater does not only depend on its chemical characteristics: physical phenomena such as ionization and radioactivity also play a crucial role [35,36]. Saturated with organic substances, seawater resembles a large fertile broth composed of amino acids and microorganisms, including mucosin and the flora and fauna that make up plankton. These microorganisms are involved in assimilating minerals suspended in the water, but they also actively fight foreign microbes, hence their antibacterial and antibiotic effect. Marine life is also 'populated' by chemical messages of all kinds, substances produced and released in seawater by any animal or plant species, and capable of acting remotely on the behaviour or biological processes of these same species or others [37,38]. Since 1962, these biochemical mechanisms observed in various organisms (bacteria, plankton, metazoans, vertebrates) have ceased to be hypotheses to become widely established scientific facts. In 1970, Maurice Aubert, founder of INSERM and the International University of the Sea (formerly Cerbom), proposed the term 'telemediators' to define those signals released into the marine environment. These chemicals of very different natures (repulsive, sexual, toxic, antibiotic, etc.) are also very fragile. Because of the multiplicity of signals discovered, this system of relationships, in which the biochemical message is the pivot around which the ocean biological balance is organized, constitutes a new type of approach in marine biology [39,40,41]. The use of sea extracts in this experiment significantly affected seed germination and plant development of *Cichorium intybus* and *Carthamus tinctorius*. Also, it showed an increase in substrate microfauna, probably due to all the mineral and organic substances present in the seawater. Also interesting was the mineral increase in the vegetative tissues, undoubtedly mediated by microbial activity. There was also a significant reduction in seedling mortality compared to the control. A particularly interesting aspect was that the theses with FertilTomix during the cultivation cycle did not receive essential fertilization as the control and the biostimulant algae treatment did, so the increase in plant growth was entirely attributable to the sea mineral product. The trial confirms significant results from other Chinese and American trials on vegetable and fruit plants [14,16].

5. Conclusion

The test showed a significant effect on plant growth of certain extracts obtained by an innovative mineral process from seawater. The test also showed how mineral and organic substances in seawater could have a significantly positive influence on soil microfauna with direct and indirect effects on plant growth and defence. The results obtained are particularly interesting for people who have to cultivate in arid environments or without drinking water, as well as those who want to start reducing the use of fertilizers of industrial origin. New experiments are currently underway to evaluate the recycled water obtained from the process of extracting minerals from the sea and assess whether it can be used in agriculture.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflict of interest.

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