Revue Agrobiologia
www.agrobiologia.net
ISSN (Print): 2170-1652
e-ISSN (Online): 2507-7627

STUDY OF THE EFFECT OF BROWN SEAWEED AS BIO -FERTILIZER ON THE QUALITY OF TWO TOMATOES (*SOLANUM LYCOPERSICUM* L.) VARIETIES

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Reçu le 24/01/2021, Révisé le 28/05/2021, Accepté le 11/06/2021

Abstract

Description of the subject: The topic of the present study is testing and evaluating the effect of a foliar bio fertilizer founded on extracts of brown seaweed on tomato fruit quality.
Objective: Is to define effect of different doses of bio fertilizer and observe if this could improve the quality and meet the requirements of the consumer.
Methods: Four concentrations of bio fertilizer: 25%, 50%, 75%, 100%, applied to two varieties of tomatoes, for evaluations of their organoleptic and nutritional parameters, in various stages of development, and comparison with controls.
Results: A significant differences were observed on the index of flavour (Brix/acidity), rates of chlorides, ashes and proteins. The dose of 75% (2.5 mL/L) for the market garden variety and at the dose of 50 % (1.5 mL/L) for the industrial variety showed qualitative improvements of fruits.
Conclusion: Organic fertilisers based on brown marine algae had beneficial effects on the organoleptic and nutritional quality of tomatoes. These bio fertilizers could use as an alternative for chemical fertilizers to produce a better tomato fruit.
Keywords: bio fertilizer; brown algae; tomatoes; quality parameters.

ÉTUDE DE L'EFFET DES ALGUES MARINES BRUNES COMME BIO-FERTILISANT SUR LA QUALITÉ DE DEUX VARIÉTÉS DE TOMATES (*SOLANUM LYCOPERSICUM* L.)

Résumé

Description du sujet : Le sujet de la présente étude est de tester et d'évaluer l'effet d'un bio fertilisant foliaire basé sur des extraits d'algues marines brunes sur la qualité des fruits de tomates.
Objectifs : Est de définir l'effet des différentes doses du bio fertilisant et d'observer si cela pourrait améliorer la qualité et répondre aux exigences du consommateur.
Méthodes : Quatre concentrations de bio fertilisant : 25%, 50%, 75%, 100%, appliquées à deux variétés de tomates, pour l'évaluation de leurs paramètres organoleptiques et nutritionnels, à différents stades de développement, et la comparaison avec les témoins.
Résultats : Des différences significatives ont été observées sur l'indice de flaveur (Brix /acidité), les taux de chlorures, de cendres et de protéines. La dose de 75% (2,5mL/L) pour la variété maraîchère et de 50% (1,5 mL/L) pour la variété industrielle ont montré des améliorations qualitatives des fruits.
Conclusion : Cette expérimentation a montré que les fertilisants organiques à base d'algues marines brunes ont eu des effets bénéfiques sur la qualité organoleptique et nutritionnelle des tomates. Ces engrais naturels peuvent remplacer les engrais chimiques pour produire un meilleur fruit de tomate.
Mots clés : bio fertilisant ; algues brunes ; tomates; paramètres de qualité.

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INTRODUCTION

Seaweed as bio fertilizers could be an important in organic agriculture. Today in many countries seaweed is consumed as food. On the other hand, it is also used as green-manure for crops cultivated along coastal areas; one of the reasons is their high content of carbon-based compounds [1]. Nowadays, consumers prefer products grow in organic with less input of chemicals, which could have beneficial effects for the environment and human health. The benefits of the use of bio fertilizers have been reported earlier [2]. They are found to be superior over chemical fertilizer due to high level of organic matter, macro and micro elements, vitamins, fatty acids and also the growth regulators [3]. Moreover, other reports indicated that bio fertilizers enhanced some biochemicals parameters such as photosynthetic pigments, carbohydrates, free amino acids, proteins, total soluble sugar and ascorbic acid content of crop plants [4, 5] and improuved fruit quality [6, 2]. As they holds a place of choice in the fruit diet and fresh vegetables [7], tomatoes (*Solanum lycopersicum* L.) were chosen to test the effect of seaweed fertilizer on their quality. In addition, they are cultivated worldwide and are used in diverse kind of foods, consumed raw, cooked or processed. Tomatoes have health stimulating properties, as fruits are low in calories, rich in water, and are an excellent source of mineral salts, nutrients, amino acids, organics acids, carbohydrates and antioxidants such as carotenoids (lycopene and βcarotene) [8], and vitamins (ascorbic acid and α-tocopherol) [9]. These powerful antioxidants are involved in the prevention of cardiovascular diseases and various types of cancers [10, 11]. Consumers select tomatoes in shops using sensorial organs. The flavour is one of the most important criteria of appreciation of tomatoes [12]. This organoleptic quality is closely related to sugars and acids content [13, 14] and to sugars/acids ratio [15]. The nutritional quality, as proteins content is also an essential selection criterion of consumption. The aim of this study, appraise the effect of brown seaweed as bio fertilizer on the quality of two tomato varieties (market garden Saint-Pierre and the industrial Rio-Grande) and the outcome of different doses of bio fertilizer on diverse parameters involved in the intrinsic quality.

MATERIAL AND METHODS

1. Plant material

The test was conducted in a polymethyl methacrylate greenhouse at the experimental station of Saad DAHLEB University Blida 1, Soumaa road and the analyses were carried out at the research Laboratory of Plant Biotechnologies of Blida 1 University and at the Laboratory of the Technical Institute of Fruit and Vine Arboriculture (ITAFV) of Tassala El-Mardja, Birtouta-Algiers. Two varieties of tomato: market tomato (Saint-Pierre) and industrial tomato (Rio Grande), cultivated on pots with 5L capacity. A growing substrate containing (2/3 of soil+1/3 of peat) were used for all treatments. Four foliar doses of brown seaweed as bio fertilizer were sprayed to tomato plants and compared with the control (without bio fertilizer).

2. Composition of the bio fertilizer

The composition of bio fertilizer was a mixture of seaweeds extracts having the following compounds: vegetable matter are 10%: basically extracts of brown algae (*Laminaria digitata*) and (*Ascophyllum nodosum*); Free amino acids, enzymes and collagens 10%; Total nitrogen 11.5% (Ammonia nitrogen 0.01%, Nitric nitrogen 0.06%; Ureic nitrogen 7.13%; Protein nitrogen 1.5%, Organic nitrogen 1.5%, Amino nitrogen 1.3%) and 68% of distilled water.

3. Experimental design

The experiment was performed using a total randomization design, having an essential factor which was the dose of the bio fertilizer and five repetitions. The factor dose of the bio fertilizer had four levels (25%, 50%, 75% and 100%) compared to a control at (0%) without bio fertilizer.

4. Applied treatments

For both tomato varieties, four doses of foliar applications of liquid bio fertilizer were applied at different concentrations (25%, 50%, 75%, and 100%); at different plant stages development. (T0): (Control) (0%) of bio fertilizer (water), (T1): dose of 25% equivalent to the concentration of 0.75mL of bio fertilizer /L of water, (T2): dose of 50% equivalent to the concentration of 1.5mLof bio fertilizer /Lof water , (T3): dose of 75% equivalent to the concentration of 2.5mL ofbio fertilizer /L of water, (T4): dose of 100% equivalent to the concentration of 3mL of bio fertilizer /L of water.

The concentration of bio fertilizer in water was calculated in relation to the maximum dose of 3mL /L equivalent to 100% of the bio fertilizer.

5. Application tomato plant stages

Tomato seedlings were transplanted into the pots after forty days (40) of nursery. The application of bio fertilizer treatments has been carried out at each stage of the development of tomato.

(i) Vegetative stage: corresponding to 4 and 5 leaves (2 days after transplantation);

(ii) At the beginning of flowering: corresponding to 10 % of flowering (50 days after transplantation); *(iii)* Full blooming or flowering: corresponding to 75% of flowering (64 days after transplantation);

(iv) Start fructification: corresponding to 10 % of fructification (73 days after transplantation);

(v) Full fructification: corresponding to 75% of fructification (83 days after the transplantation);

(vi) Swelling of fruits: (98 days after transplantation).

6. Parameters analyzed

- *Index of flavour (Brix/acidity ratio):* The Brix / acidity ratio was calculated for each treatment. The ratio allows the evaluating of the flavour of the fruit and taste quality. Soluble solids or °Brix (refractive index) indicate the sucrose concentration of an aqueous solution having the same refractive index as the analysed product. Measured at 20°C using the refractive index, and expressed as the percentage by mass. The soluble dry matter is determined by standardized method (NA 5669) [16] using a universal Abbe refractometer (EEC 1764/86) (ISO 2173) [17]. The total acidity of natural organic acids (Citric acid principally and malic acid) was determined using a standard titration method (NA 691) and (NF V05-101) [18].Tomato juice was used with a strong base (NaOH N/10) by turning with a few drops of phenolphthalein as a coloured indicator. The neutrality is reached when the indicator turns pink. Citric acid monohydrate is considered the predominant acid in tomato, so it is used in the expression of results according to a standardized method [13].

- *Rate of chlorides:* Chlorides express the rate of Salinity of the food. Their dosage was done using a volumetric normalized method (EEC 1764/86) (CACQE N°08.96.13) [19].The sample (tomato juice) was added with an excess of silver nitrate and nitric acid to ensure precipitation of silver chloride. Excess $AgNO_3$ is measured with a solution of ammonium thiocyanate in the presence of ammoniacal ferric alum as an indicator. The chloride content is expressed as percentage by mass of sodium chloride (%).

- *Rate of ashes:* Ashes express as residue after combustion (inorganic portion) containing mineral elements. The rate of ashes is determined by the method described by AFNOR, 1982 [20]. For our studies samples of 2 grams of dried tomato, were crushed and place on porcelain capsules and put in an oven adjusted to 550±15°C for five hours, up to then turn a grey / whitish colour. After cooling the capsule was weighed. The results are expressed to the nearest 0.01 as a percentage relative to dry matter (%).

- *Protein content:* The proteins rate in fruit tomato was determined using the KJELDHAL method [21]. The rate of proteins was calculated from the nitrogen content by means of a conversion factor of 6.25. (Proteins g=6.25×N) As it is well known that proteins contain an average of 16% nitrogen, The results are expressed to the nearest 0.1 as a percentage relative to dry matter (%). K= conversion factor (%); N= nitrogen content of test sample (%).

7. Statistical analysis

The obtained results were subjected to an analysis of variance (ANOVA) using the STATITCF software, (version 5, 1991). The averages are compared according to the Newman and Keuls which measures the smallest significant amplitude (PPAS) at significance level of <5% to identify and classify the different homogeneous groups.

RESULTS

1. Brix/acidity

The analysis of the variance showed a highly significant concerning the effect of the treatment, on the gustative quality for both varieties Saint-Pierre (p=0.001) and Rio-Grande (p=0.004).The Newman and Keuls test at 5% threshold confirms differences to the homogeneous groups. The values obtained for Saint-Pierre varies between 6.72 and 12.37 (table 1). The highest value is obtained with plants of treatment T4 (dose 100%) corresponding to the concentration (3mL/L) of the bio fertilizer. For industrial tomatoes Rio-Grande, (Brix / acidity) values range from 4.40 to 8.36 (table 2). The highest value is obtained with treatment T3 (dose 75%) corresponding to the concentration (2.5mL/L). Compared to treatments, the control showed low values.

Table1: Parameter of quality for the garden-market tomato

	Variety Saint -Pierre				
P ＼ T	T0	T1	T2	T3	T4
Brix/acidity	6.72±0.41^{b}	10.95±1.02^{a}	9.91±1.61^{a}	10.94±1.30^{a}	12.37±1.21^{a}
Chlorides (%)	0.19± 0.26^{c}	0.22±0.11b^{c}	0.24±0.27^{b}	0.25±0.32^{ab}	0.29±0.41^{a}
Ashes (%)	09.42±0.31^{b}	09.45±0.04^{b}	8.49±0.28^{c}	10.50±0.69^{a}	10.02±0.50^{ab}
Proteins (%)	10.81±0.29^{b}	10.99±0.12^{b}	12.54±0.31^{a}	12.15±0.00^{a}	12.96±0.87^{a}

P: parameter; T: treatments; a, b, c and d: homogeneous groups

Table 2: Parameter of quality for the industrial tomato

	Variety Rio-Grande				
P ＼ T	T0	T1	T2	T3	T4
Brix/acidity	4.40±0.16^{b}	5.23±1.16^{b}	7.78±1.93^{a}	8.36±0.54^{a}	6.71±0.14^{ab}
Chlorides (%)	0.20±0.31^{b}	0.24±0.27^{ab}	0.26±0.52^{ab}	0.27±0.32^{a}	0.24±0.26^{ab}
Ashes (%)	09.52±0.15^{b}	09.67±0.25^{ab}	09.86±0.09^{ab}	9.94±0.26^{a}	10.00±0.28^{a}
Proteins (%)	14.12±1.34^{b}	15.75±1.76^{ab}	18.97±0.89^{a}	15.61±0.92^{ab}	17.94±1.74^{a}

P: parameter; T: treatments; a, b, c and d: homogeneous groups

2. Chlorides

The analysis of the variance of this technological parameter, revealed a very highly significant on treatments for the market garden tomato (p=0.000) and significant for the industrial tomato (p=0.043). The rate of chlorides contained in tomatoes Saint-Pierre variety, varies from (0.19% to 0.29%) (table1). The foliar applications of the bio fertilizer at 75% and 100%, increase chloride levels for this market tomatoes (table1); the highest value (0.29%), is obtained with treatment T4 corresponding to the foliar application (dose of 100%), equivalent to the concentration (3mL/L) of the bio fertilizer, followed by T3 (dose of 75%) equivalent to the concentration (2,5mL/L).The rates of chlorides of industrial tomatoes are between (0.20% and 0.27%) (table 2). The highest chloride levels were obtained with treatments T3 and T2 corresponding to their respective doses of 75% (2.5mL/L) and 50% (1.5mL/L).

3. Ashes

The analysis of variance for ash content showed a very highly significant on treatments (p= 0.000) for the variety Saint-Pierre and a significant difference (p=0.013) for tomatoes of the variety Rio-Grande, indicating that was a treatment effect on tomato ashes. The Newman and Keuls test at the 5% threshold reveal a significant difference between the homogenous groups. The rates of ashes of the garden tomatoes vary between (8.49% and 10.50%) (table 1). The foliar application of treatment T3 (dose of 75%) corresponding to the concentration (2.5mL/L) has the fore most value; the lowest value has been obtained with treatment T2 (dose of 50%) corresponding to the concentration of (1.5Ml/L).

For industrial tomato, ash content was between (9.52% and 10%) (table 2); the high level was recorded at the dose of 100 % (3ML/L).

4. Proteins

The analysis of variance showed a very highly significant (p=0,000) on the protein content of tomato fruits of the Saint-Pierre variety and high significant (p=0.010) for the Rio-Grande variety. The significant amplitude test at 5% revealed two homogeneous groups for both varieties of tomatoes. Protein levels obtained for the market garden tomatoes vary between (12.81% and 12.96%) (table 1). For industrial tomato vary between (14.12 % and 18.97%) (table 2). For both varieties greatest protein values were obtained with the homogeneous group specific to the concentration 50% equivalent to (1.5mL/L). However, we notice that industrial tomatoes exceed on protein values to market garden tomatoes.

DISCUSSION

Tomato flavour is a complex interaction of aroma (volatile) and taste (non volatile) [22, 23]. Non volatile compounds such as solide soluble and titratable acidity, plays a great role in determinig flavour of the fruit [24]. The best tomato flavour is associated with (Brix / acidity) ratio [25, 26]. It is an indicator of commercial maturity and maturity for consumption [27]. According to standards Namestnikov [28] and Verxhivkerands & Galkina [29], this ratio (Brix/acidity) must be greater than or equal to seven, to obtain the best taste of the tomato and to guarantee a good technological quality. Our results showed that tomato variety Saint-Pierre treated with bio fertilizer was closed to the standard value indicating a good technological quality.

For the Rio-Grande variety, the control and treatment T1 (dose of 25% corresponding to 0.75mL/L) of the bio fertilizer; showed low quality since their respective values (4.40 and 5.23) are low compared to the standard. The treatment T4 dose of 100% showed a value slightly lower than the standard (at the limit). For that reason, their flavour could be affected as may be levels of imbalance between sugar and acidity. These results are in agreement with those of the authors Saltveit [25] and Yahia & Brecht [30] who reported that tomato fruits high in both acids and sugars have excellent flavour, while bland tomatoes have low acidity and tart tomatoes have low sugar content. Indeed, during the ripening of the fruit, there is a change in the levels of sugars, acids and volatile compounds [31, 32], which would reduce their taste quality. Therefore, these tomatoes are not recommended for processing or for table consumption. However, treatments corresponding to the 50% (1,5mL/L) and 75% (2,5mL/L) appear to give good quality for the processing industry. Also, we notice that values of (Brix/Acidity) ratio, obtained in this study, are higher for fresh market tomatoes than those of processing tomatoes. Regarding chlorides, the gustative function of sodium chloride (NaCl), is a very important parameter of quality. Besides its antibacterial virtue, it is an essential micronutrient and, via salt taste, it is appetitive. Sodium improves the sensory properties of foods [33]. The variation of its rate affects the expression of the Brix index [34]. The chlorides values obtained in this study, showed that the used seaweed as bio fertilizer acted positively by increasing of chlorides in the tomatoes fruits. Our results are closer to those found by Jayaraman et *al.* [35]. It is mainly related to the amounts of mineral elements in seaweeds as asserted by Nwosu et *al.* [36]. The application of the seaweeds extracts may enhance elements contained in the cultivated plants and could leads to the improvement of the quality and the increase of the yield [37]. Ashes represent the total quantity of minerals salts in a sample. A tomato fruit contain about 8% of minerals of dry matter. Observing the control, we notice in general, that the bio fertilizer increases the ash levels, when the doses were increased for both varieties, indicating the positive effect of the bio fertilizer. This could represent the increase of mineral elements in plants [36]. These results are in accordance with earlier studies reported by Zodape et *al.* [2]. In fact, brown algae are a rich source of minerals [36]; sometimes they were exceeding 40% [37]. Therefore, the micro and macronutrients provided by the seaweed bio fertilizer contribute to the quality of tomato fruit as asserted by Gupta et *al*. [38]. In the same way, minerals could indirectly affect the taste of tomato fruit [39]. With regard to proteins, they represent 8% of dry matter [40].This proteins are functional and essential for the quality of tomato, and are involved as enzymes in plant growth and in the metabolism of fruit maturity, they indirectly contributing to flavour [41]. The present work showed that protein contents in Rio-Grande variety were higher than the Saint-Pierre variety. These could be explained as the fruits of industrial tomatoes contain high dry matter than market garden tomato. Therefore, protein content in tomato fruit may be influenced by variety. Our results agreed with previous values reported that indicated fruit composition of primary compounds and secondary metabolites depends on cultivars [42], and they develop with degree of maturity of the fruit [43]. Our results could indicate that bio fertilizer stimulated the nutritional quality of tomato fruits, as improves protein levels. They represent a rich source in essential amino acids [44] that are essential to the food flavour [45]. They are also rich in phytohormones, such as IAA, IBA, giberellins and cytokinin [46], which enhanced the biochemical composition on fruits by increasing the photosynthetic activity, which, stimulates the synthetises of carbohydrates and improves protein levels. Similar observations were reported previous Kumari & Bhatanagar [5] and Gurusaravanan et *al.* [47].

CONCLUSION

Foliar applications based on marine algae have provided indications that could improve the flavour of tomato fruits. Fresh market tomatoes Saint-Pierre variety have benefited from good technological qualities with all treatments. However, the industrial tomatoes Rio-Grande variety, obtained good technological qualities regardless of the dose received. The quality of these processing tomatoes improves only when they received the treatments with doses of 50% and 75% of a liquid bio fertilizer.

The most efficient and balanced doses in our study for all quality parameters Brix/Acidity, chlorides, ashes and proteins were 75% (2.5mL/L) for garden tomatoes and 50% (1.5mL/L) for industrial tomatoes. Flavour is not an isolated parameter but depends on the levels of chlorides, ashes and proteins.

This experiment shows that the quality of fruit depends not only on the doses administered to tomatoes, but also on environmental factors and adopted cultural techniques. On the basis of these results, we showed that bio fertilizers based on brown marine algae had beneficial effects on the organoleptic and nutritional quality of tomatoes. Bio fertilizers are a source of mineral elements, carbohydrates and bioactive substances that stimulate photosynthetic activity and therefore modify the biochemical composition of tomato fruits. Moreover, the use of this evaluable bioresource is very interesting in agriculture because it is environmentally friendly, degradable and it is one of the mean to substitute the chemicals and reduce the cost production.

Acknowledge

We are thanks to:
Professor Ricardo HOLGADO from NIBIO (Norwegian Institute for Bio economy Research), Norway, for the constructive comments to the document.
Tassalat El-Mardja, Chef of Department and ITAFV Laboratory Team (Technical Institute of Fruit and Vine Arboriculture), Algeria.
We are also thankfully to the Laboratory Director and Team SIM of Blida, Algeria.

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