How Does Compost Amendment Affect Stevia Yield and Soil Fertility? †

El Hocine Hirich 1,2,*, Brahim Bouizgarne 1, Abdelmjid Zouahri 3, Oumaima Ibn Halima 3 and Khalid Azim 2

1 Laboratory of Plant Biotechnology, Team of Microbial Biotechnology, Faculty of Sciences, Ibn Zohr University, Agadir 80000, Morocco; b.bouizgarne@uiz.ac.ma
2 Research Unit of Integrated Plant Production, Regional Centre of Agricultural Research, Avenue Ennasr, BP 415 Rabat Principale, Rabat 10090, Morocco; khalid.azim@inra.ma
3 Regional Centre of Agricultural Research, National Institute of Agronomic Research, Avenue Ennasr, BP 415 Rabat Principale, Rabat 10090, Morocco; abdelmjid.zouahri@inra.ma (A.Z.);
ibnhalima@gmail.com (O.I.H.)

* Correspondence: hirich.elhocine@gmail.com; Tel.: +212-697558737
† Presented at the 2nd International Laayoune Forum on Biosaline Agriculture, 14–16 June 2022; Available online: https://lafoba2.sciforum.net/.

Abstract: Stevia (Stevia rebaudiana) is a plant species belonging to the family Asteraceae. It contains natural intense sweeteners while presenting low carbohydrate content. Its insignificant effect on blood glucose makes its consumption possible for diabetic and hypoglycemic diets. Chemical fertilizers have a negative impact on the stevia leaves quality. Organic farming has become essential in producing medicinal plants such as Stevia to boost stevia growth with stevioside and rebaudioside-A content.

The purpose of this study was to evaluate the effect of four compost doses, i.e., 0, 10, 20, and 30 t/ha on Stevia yield and soil fertility. This experiment was conducted in the Melk Zhar experimental domain, Belfaa of the National Institute of Agronomic Research (INRA), Agadir, Morocco during the period of February-June 2020. The obtained results revealed that increased compost doses significantly increased yield and soil fertility i.e., phosphorus; P, potassium; K and organic matter; OM contents.

The highest yield (2.19 t/ha) was observed under treatment using 30 t/ha of compost followed by 20 t/ha (1.67 t/ha), and the lowest (1.50 t/ha) under control conditions. The highest OM content (1.02%) was found under treatment with 30 t/ha of compost while the lowest (0.85%) was under the control. The soil analysis also showed that the application of compost at 20 t/ha resulted in the highest P (28.68 ppm) and K (125.5 ppm). In the light of finding, it is concluded that the application of compost at 30 t/ha is the most effective recommended rate for improving Stevia yield and soil fertility.

Keywords: phosphorus; potassium; nutrients; organic matter; soil fertility; Stevia; yield

1. Introduction

Stevia (Stevia rebaudiana Bertoni) is native of South American (Paraguay and Brazil), however, its cultivation as medicinal plant is spreading across the world. Worldwide, there are more than 100 species of Stevia are available. It produces sweet molecules called steviol glycosides (SG) [1]. The most important steviol glycosides in stevia leaf are stevioside (5–10% of dry leaf weight), which is approximately 300 times sweeter than sugar, and rebaudioside A (2–4%), which is better suitable for usage in food and beverage than Stevioside owing to its pleasant flavor [2].

In conventional agriculture systems, the application of agrochemicals has increased, which is resulting in increased residual content of those chemicals in therapeutic medicines. There is an increased danger of health risks and environmental issue because of the indiscriminate use of chemical fertilizers and pesticides. Compost and other organic fertilizers, when applied, can increase nutrient availability of the crops and assist to improve soil health. Organic fertilizers are good alternatives to inorganic fertilizers since they increase
soil quality. One of the most recent breakthroughs is the adoption of organic fertilizers, which delays nitrification for an extended period and boosts soil fertility. The use of organic fertilizers in conjunction with integrated nutrition management has been shown to boost Stevia output [3]. Further, the use of organic fertilizers such as compost is beneficial in reducing environmental concerns caused by chemical fertilizers. Thus, the objective of this study was carried to determine the effect of various levels of compost on Stevia yield and soil fertility under arid climate of Souss Massa region in Morocco.

2. Material and Methods

2.1. Experimental Site and Design

This experiment was conducted in the Melk Zhar Experimental station, Belfaa of the National Institute of Agronomic Research (INRA), Agadir, Morocco (30°2’33” N; 9°33’4” W). The physico-chemical properties of the soil are presented in Table 1. The study focused on the growth of Stevia under four different levels of compost (0, 10, 20, and 30 t/ha) during the period of February–June 2020. These treatments were implemented in a randomized complete block design containing 4 plots with an area for each of (62 m × 34 m = 2108 m²). The planting density is approximately 80,000 plant/ha.

Table 1. Physico-chemical characteristics of the soil of the experimental plots at the Melk Zhar experimental station.

| Parameters                 | 2020                      |
|----------------------------|---------------------------|
| Electric conductivity (dS/m) | 0.10 ± 0.01               |
| pH                         | 8.24 ± 0.18               |
| Clay (%)                   | 8.80 ± 1.20               |
| Fine silt (%)              | 4.73 ± 1.52               |
| Coarse silt (%)            | 3.74 ± 1.75               |
| Fine sand (%)              | 60.54 ± 1.65              |
| Coarse sand (%)            | 22.45 ± 1.74              |
| Organic matter (%)         | 0.86 ± 0.42               |
| Potassium (ppm)            | 687.3 ± 765.25            |
| Calcium (ppm)              | 23,548.5 ± 6258.25        |
| Sodium (ppm)               | 1235.3 ± 525.68           |

2.2. Observations Recorded

2.2.1. Analytical Methods

Soil samples were collected from four plots at 25 cm deep using auger. The soil samples were spread and air dried for 48 h in the laboratory. Then, it was passed through a 2 mm mesh sieve to remove the coarse materials and retained only the fine soil to analyze available phosphorus (P), exchangeable potassium (K), and organic matter (OM). Table 2 shows the different methods used for the analysis of these elements.

Table 2. Methods used for soil fertility analyses.

| Element    | Method                        |
|------------|-------------------------------|
| Phosphorus | Olsen [4]                     |
| Potassium  | Flame spectrophotometer [5]   |
| Organic matter | Spectrometry [6]     |

2.2.2. Yield Parameters

To evaluate the effects of different doses of compost on yield (dry leaf yield), the plants from each plot were manually harvested 10 cm above the base of the stem at the end of the growth season (June 2020). Leaf samples were collected just before blooming to analyze steviol glycoside concentrations in the leaves, at this stage steviol content are at their highest [7]. Once cut, the fresh plants were dried immediately. The drying was
carried out under natural conditions under the sun using a delta tunnel for a period of 2 to 5 days depending on the climatic conditions.

3. Results

The analysis of variance statistical analysis showed a significant (<0.001) difference among the four compost treatments in the yield and P content, while no differences among the three doses and the control in OM and K levels were noted (p < 0.000). This indicates that compost affected yield and P content and did not affect K and OM contents. The results obtained (Figure 1a) showed that the highest yield (2.19 t/ha) was obtained after treatment with a compost dose of 30 t/ha followed by 20 t/ha (1.67 t/ha), and the lowest yield (1.50 t/ha) was observed under control conditions. Regarding soil fertility (Figure 1b), the highest OM content (1.02%) was found with 30 t/ha of compost, and the application of 20 t/ha resulted in the highest values of the remaining nutrients in the soil after harvest, equal to 28.68 and 125.5 ppm for P and K contents, respectively.

![Figure 1a](image1_a.png) ![Figure 1b](image1_b.png)

**Figure 1.** Impact of compost amendment on Stevia yield (a) and soil fertility (b). The average values given by the same letters are not significantly different in ANOVA and the Tukey test (p < 0.05). Lowercase letters (a, b, c and d) indicate significant differences between treatments.

4. Discussion

Chemical fertilizers increased food production while posing a cost to the climate. Furthermore, Stevia produced through the application of chemical fertilizers has been linked to health issues according to some customers. As a result, research communities are searching for alternatives to agrochemicals [8]. Organic amendments such as composts, are an effective alternative to inorganic fertilizers and improve the production and development of Stevia in a sustainable way [9]. Compost enhanced the OM and nutritional content such as P and K of the soil, which had a good influence on Stevia yield, as had been reported in other crops [10]. Stevia has reduced nutritional requirements and can be easily adapted in poor soil quality [11]. On the other hand, a nutrient deficit can be harmful [12]. The higher yield of Stevia with compost might be due to better nutrient availability near the root zone. In fact, it is well recognized that increased productivity due to compost application helps to reduce the use of artificial fertilizers and hence boost the sustainability of stevia production [13].

5. Conclusions

The impact of compost on a crop is observed in the medium term and thereafter, concluding that recommendation of one of the three doses over the others is not supported for this first year of testing. The finding indicates clearly that Stevia responded positively to increased organic amendment dose and the optimal rate is 30 T/ha. As perspective,
we recommend increasing further the amendment dose and minimizing the size of the experimental plot around 2000 m$^2$ and concentrate the factors studied while studying the economic impact of the tested solutions and estimating their cost.

Author Contributions: A.Z. project coordinator; E.H.H., O.I.H. and K.A. conceived and designed the experiments; E.H.H. performed the experiments and analyzed data under the supervision of K.A. and B.B.; E.H.H. wrote the paper under the supervision of K.A. and B.B.; All authors have read and agreed to the published version of the manuscript.

Funding: The research was carried out as part of a project for the development and exploitation of stevia culture in organic mode at the Agadir regional center of the National Agricultural Research Institute and funded by the COSUMAR group.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to thank COSUMAR for the financing of the project, and the Agadir regional center of the National Agricultural Research Institute for providing research facilities, material and the supervision to undertake this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Díaz-Gutiérrez, C.; Hurtado, A.; Ortiz, A.; Poschenrieder, C.; Arroyave, C.; Peláez, C. Increase in steviol glycosides production from Stevia rebaudiana Bertoni under organo-mineral fertilization. *Ind. Crops Prod.* 2020, 147, 112220. [CrossRef]

2. Benhmimou, A.; Ibriz, M.; Al Faïz, C.; Gaboun, F.; Shaimi, N.; Amchra, F.Z.; Lage, M. Effects of water stress on growth, yield, quality and physiological responses of two stevia (Stevia rebaudiana Bertoni) varieties in Rabat region, Morocco. *Asian J. Agric. Biol.* 2018, 6, 21–34.

3. Coelho, L.; Osório, J.; Beltrão, J.; Reis, M. Organic compost effects on Stevia rebaudiana weed control and on soil properties in the Mediterranean region. *Rev. Bras. Cienc.* 2019, 42, 109–121.

4. Sims, J.T.; Edwards, A.C.; Schoumans, O.F.; Simard, R.R. Integrating soil phosphorus testing into environmentally based agricultural management practices. *J. Environ. Qual.* 2000, 29, 60–71. [CrossRef]

5. Kamentsky, L.A.; Melamed, M.R.; Derman, H. Spectrophotometer: New instrument for ultrarapid cell analysis. *Science* 1965, 150, 630–631. [CrossRef] [PubMed]

6. ISO 14235:1998; Qualité du sol—Dosage du Carbone Organique par Oxydation Sulfochromique. ISO: Geneva, Switzerland, 1998.

7. Guzman, R.D. Autoecological Role of Steviol Glycosides in Stevia rebaudiana. Ph.D. Thesis, Central Queensland University, Rockhampton, Australia, 2011.

8. Bidabadi, S.S.; Afazel, M.; Pooede, S.D. The effect of vermicompost leachate on morphological, physiological and biochemical indices of Stevia rebaudiana Bertoni in a soilless culture system. *Int. J. Recycl. Org. Waste Agric.* 2016, 5, 251–262. [CrossRef]

9. Sharma, S.; Wali, S.; Singh, B.; Kumar, R. Comprehensive review on agro technologies of low-calorie natural sweetener stevia (Stevia rebaudiana Bertoni): A boon to diabetic patients. *J. Sci. Food Agric.* 2016, 96, 1867–1879. [CrossRef] [PubMed]

10. Reis, R.V.; Chierrito, T.P.; Silva, T.F.; Albiero, A.L.; Souza, L.A.; Gonçalves, J.E.; Gonçalves, R.A. Morpho-anatomical study of Stevia rebaudiana roots grown in vitro and in vivo. *Rev. Bras. Farmacogn.* 2017, 27, 34–39. [CrossRef]

11. Ramesh, K.; Singh, V.; Megeji, N.W. Cultivation of stevia [Stevia rebaudiana (Bert.) Bertoni]: A comprehensive review. *Adv. Agron.* 2006, 89, 137–177.

12. Utumi, M.M.; Monnerat, P.H.; Pereira, P.R.G.; Fontes, P.C.R.; Godinho, V.D.P.C. Macronutrient deficiencies in Stevia: Visual symptoms and effects on growth, chemical composition, and stevioside production. *Pesqui. Agropecu. Bras.* 1999, 34, 1038–1043. [CrossRef]

13. Zaman, M.M.; Rahman, M.A.; Chowdhury, T.; Chowdhury, M.A.H. Effects of combined application of chemical fertilizer and vermicompost on soil fertility, leaf yield and stevioside content of stevia. *J. Bangladesh Agric. Univ.* 2018, 16, 73–81. [CrossRef]