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The Effect of Spraying Boron, Potassium, and Seaweed Extract on The Nutrient and Chlorophyll Content of Apple Tree Leaves

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Abstract

This study was conducted in the Kassab area in Lattakia to examine the effect of spraying apple trees with marine algae extract, potassium, and boron. It dealt with eight factors: spraying with potassium (0.5%), boron (0.2%), marine algae extract, mixing potassium and boron, potassium and algae, algae, potassium, and boron, and with water only. The complete randomized design was used covering 24 trees with each transaction having 3 trees with one repeater tree. Averages were compared by the GenStat program and the lowest moral extent. The leaf content of nutrients and chlorophyll was significantly affected. The findings showed an increase in the ratios of nitrogen-phosphorus-potassium-calcium-magnesium-boron and total chlorophyll in the leaves. The nitrogen content of the leaves increased significantly by 2.447% when sprayed with marine algae extract for an average of two years compared to 1.63%. The marine algae extract treatment offered the highest phosphorous at 2.447%. The treatment with boron, potassium and marine algae outperformed the others for the two years at 1.203% and 1.293%, respectively. The boron treatment gave a significant effect over the others at 0.551%. The interaction between boron, potassium and marine algae showed remarkable improvement over the rest with the boron content in the leaves reaching 46.21 pm. For leaf chlorophyll content, the mixing treatment of potassium and boron outweighed the rest

at 2.22 mg/g compared to the 1.29 mg/g for the control and exceeded that for marine algae extract of 2.30 mg/g while the control had 1.41 mg/kg. Total chlorophyll content for the boron and potassium was highest at 4.25 mg/g compared to the control (2.70 mg/g).

Keywords: Foliar application, Leaves, Minerals, Chlorophyll, Apples.

تأثير الرش الورقي لأشجار التفاح بالبورون والبوتاسيوم ومستخلص الطحالب البحرية في محتوى الأوراق من العناصر الغذائية والكلوروفيل

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الخلاصة

تم إجراء هذ البحث في منطقة كسب بمحافظة اللاذقية على أشجار التفاح من صنف (Golden Delicious) بهدف دراسة تأثير التغذية الورقية ببعض العناصر الغذائية على محتوى أوراق أشجار التفاح من النتروجين، الفوسفور، البوتاسيوم، الكالسيوم، المغنزيوم، البورون، إضافة للكلوروفيل a,b والكلوروفيل الكلي. وتضمن البحث الرش بالبوتاسيوم والبورون ومستخلص الطحالب البحرية (Algi firt top) بشكل مفرد أو مزيج مع بعضها. أدى الرش بهذه المواد إلى تفوق المعاملات المدروسة مقارنة بالشاهد، النتروجين: فقد زادت النسبة لمحتوى الأوراق من النتروجين معنويا ووصل إلى 2.447% عند الرش بمستخلص الطحالب البحرية بالنسبة لمتوسط العامين مقارنة بالشاهد (1.630)%، الفوسفور: أعطت معاملة مستخلص الطحالب البحرية أعلى محتوى للأوراق من للفوسفور (2.447)%، البوتاسيوم: فقد تفوقت معاملة المزج بين البورون والبوتاسيوم والطحالب البحرية على بقية المعاملات بالنسبة لمتوسط العامين ووصل إلى 1.203%، 1.293% بالترتيب، المغنزيوم: لقد أعطت معاملة البورون تأثيرا معنويا مقارنة بباقي المعاملات حيث أعطت 0.551%، البورون: أظهرت معاملة الخلط بين البورون والبوتاسيوم والطحالب البحرية تحسنا ملحوظا مقارنة مع باقي المعاملات حيث وصل محتوى الأوراق من البورون إلى 46.21 ppm. وبخصوص محتوى الأوراق من الكلوروفيل: الكلوروفيل a تفوقت معاملة المزج بين البوتاسيوم والبورون على سائر المعاملات حيث بلغت 2.22 ملغ/غ مقارنة بالشاهد الذي كان 1.29 ملغ/غ، أما الكلوروفيل b: تفوقت معاملة مستخلص الطحالب البحرية، حيث بلغ محتوى الأوراق 2.30 ملغ/غ بينما في الشاهد 1.41 ملغ/كغ والكلوروفيل الكلي كانت معاملة البورون والبوتاسيوم هي الأفضل، حيث بلغ 4.25 ملغ/غ مقارنة مع الشاهد الذي كان 2.70 ملغ/غ.

كلمات مفتاحية: التغذية الورقية، الأوراق، المعادن، الكلوروفيل، التفاح.

Introduction

As perennial trees, apples need balanced nutrition to grow and achieve high production and high quality fruits. Apple composting systems should consider the age, production, weight, and quality of trees. Fruit quality relies heavily on multiple factors such as nutrition and resistance to diseases (16).

Good nutrient management is essential to maximize production, especially in fruit trees (27). The addition of chemical fertilizer in arbitrary amounts may be more than the plant needs and these elements wash into groundwater creating pollution (17). Hence, the importance of foliar paper spraying as a way to meet the nutrient needs of trees, as well as environmentally friendly and safe, with the correct doses of these elements targeted directly to the leaves or fruits, and in limited quantity (9).

Tree production can decrease as a result of a lack of any nutrient and the application of certain elements such as boron or potassium and calcium is closely related to the quality of fruits (30). Paper fertilizers containing large amounts of micronutrients are usually complementary to soil application and are used to quickly address nutrient deficiencies.

The leaf analysis technique is well-known for determining the nutritional status of apple trees (32). The nutrient accumulation curve in apple trees is a reliable indicator of the nutrient requirements at each stage of the plant's growth. As such, analysis of mineral leaf content is necessary to determine the adequacy, excess, or shortage of nutrients in the plant (30).

Potassium is an essential nutrient that has an important role in plant growth and increased productivity, and is considered to be a known element at all stages of the plant's life as it participates in all the physiological and biochemical processes in the plant (photosynthesis, breathing, plucking, etc.) (13 and 24). The need for potassium in fruit trees increases as they enter the fruit phase and potassium fertilizer rates applied in the orchard must be increased according to the plant's needs.

Boron is a micronutrient that plays an important role in the growth and development of the plant, the increase of flowers, and pollen plants, the ratio of fruit sets and production (1). It has an important role in several processes in plant life including cell division, hormone transfer, and diabetes transmission (25). A deficiency of boron reduces tree and vegetable growth as well as fertility and pollen germination thus affecting the content and quality of fruits (18).

Marine algae extracts are organic sources used in agricultural production and are complementary to, and not substitutes for, fertilizer (28). They contain major and micronutrients and more than a group of growth-inducing substances, such as auxins, auxin-like substances, vitamins, amino acids and organic acids, and multiple sugars that affect the plant's vital activities as well as betaine, which is a source of nitrogen (20).

The primary objective of this research was to determine the effect of paper spraying potassium, boron, and marine algae extract on the nutrient and chlorophyll content of apple tree leaves.

Materials and Methods

The research was conducted over 2021-2022 in the Kassab area of Lattakia governorate at an altitude of 900 meters above sea level which is characterized by a moderate climate, low moisture, and low alkaline lumine soils rich in organic materials.

The study involved 15-year-old trees of the Golden Delicious apple variety inlaid to the original M.M106 and cultivated in 5 * 5 m plots. The research was carried out according to the randomized complete block design (RCBD) with 8 treatments each containing 3 repeats making a total of 24 trees. The treatments were as follows:

1. Control: trees sprayed with only plain water.
2. Potassium spraying: trees were sprayed with a 2.5g/l potassium sulfate solution.
3. Boron spraying: Trees were sprayed with 2g concentrated boric acid solution equivalent to 340ppm.
4. Marine algae extract spraying: Trees were sprayed with marine algae extract (Algi First Top) at a 0.5 g/l concentration
5. Spraying with a mixture of potassium and boron: 2.5g/l + 340pm.
6. Spraying with a mixture of potassium and marine algae extract: 2.5g/potassium + 0.5g/liter.
7. Spraying with a mixture of boron and marine algae extract: 340ppm + 0.5g/l.
8. Spraying with a mixture of potassium, boron and marine algae extract: 2.5g/l + 340ppm + 0.5g/l.

The trees were sprayed three times during the growing season when they needed the nutrients during their growth cycle. The first was in the red turbocharge phase (27/3), the second after the decade (3/5), and the third a month after the second sprinkler (3/6). Each spraying session involved 5 l of the spray solution.

Indicators:

1. Paper analysis: In the second week of July each year, 25 fully developed papers were collected from each tree and fruitless branches at a rate of 90-100 for the sample of each transaction for analysis of the content of the leaves for the N- P - K -Ca - Mg-B nutrients.
2. Paper content of chlorophyll was conducted with a Spectro photometer optical spectrum device at the wavelength of 644, 663 millimeter micron.
   Chlorophyll was estimated in one gram of fresh leaf samples according to the following equations:
   Chlorophyll A = 1.07 * OD at 663-0.094 * OD at 644 mg/g.
   Chlorophyll B = 1.7 * OD at 644-0.28 * ODAT 663 mg/g.

ODD represents the optical density in light wave at lengths of 663, 644 Nm.

Results and Discussion

Content of nitrogen in leaves: Table 1 shows treatments T4, T7, T8, and T3 outperforming the others, with the lowest value in the control (T1) of 1.590% in the first year. This was repeated in the second year with T1 recording 1.670%. In terms of average for the two years, treatments T4 at 2.447% and T7 at 2.390% outperformed the rest, while the control recorded the lowest value at 1.630%.

Table 1: Effect of foliar fertilization with nutrients and seaweed extract on nitrogen content in leaves.

		Leaf Nitrogen Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	1.590 b	1.670 b	**1.630 c**
T2	K	2.003 ab	2.033 ab	**2.018b**
T3	B	2.267 a	2.190 a	**2.228 ab**
T4	SW	2.433 a	2.460 a	**2.447a**
T5	B+K	2.140 a	2.100 ab	**2.120 ab**
T6	Sw+K	2.090 ab	1.983 ab	**2.037 b**
T7	Sw+B	2.350 a	2.430a	**2.390 a**
T8	Sw+B+K	2.200a	2.280 a	**2.240 ab**

***Similar characters within the single column indicate no significant differences between them.**

Phosphorous content in leaves: As seen in Table 2, treatment T4 at 0.250% outperformed the others in year 1 followed by T8, T5, and T3 at 0.240, 0.233, and 0.233%, respectively with the lowest of 0.190% in the T1 control. In the second year, treatments T4 and T8 (0.250 and 0.250%) outperformed the rest with the control having the lowest value at 0.180%). The average for both years were in the T4 and T8 treatments which outperformed the others at 0.250 and 0.245%, respectively, while the control T1 had the lowest value of 0.185%.

Table 2: Effect of foliar fertilization with nutrients and seaweed extract on phosphorous content in leaves.

		Leaf Phosphorous Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	0.190 c	0.180 d	**0.185 c**
T2	K	0.210 bc	0.220bc	**0.215 b**
T3	B	0.233 ab	0.233ab	**0.233ab**
T4	SW	0.250a	0.250a	**0.250 a**
T5	B+K	0.233ab	0.233ab	**0.233ab**
T6	Sw+K	0.190c	0.200cd	**0.195 c**
T7	Sw+B	0.210bc	0.220bc	**0.215 b**
T8	Sw+B+K	0.240ab	0.250 a	**0.245 a**

*** Note similar characters within the single column indicate no significant differences between them.**

Potassium content in leaves: Table 3 shows that treatment T8 (1.200%) outperformed the others in the first year followed by T2 and T4 (1.030 and 1.003%), respectively, while in the second year T8 (1.213%) led followed by T2 (1.050%), with the lowest value being for T1 (0.930%). As for the two-year average, treatment T8 at 1.207% outperformed the others followed by T2 (1.040%), while the control recorded the lowest value at 0.925%).

Table 3: Effect of foliar fertilization with nutrients and seaweed extract on potassium content in leaves.

		Leaf Potassium Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	0.920c	0.930d	**0.925e**
T2	K	.030 b1	1.050b	**1.040 b**
T3	B	0.960 bc	0.963cd	**0.962cde**
T4	SW	1.003 b	1.01bc	**1.007 bc**
T5	B+K	0.990bc	0.993bc	**0.991cd**
T6	Sw+K	0.990bc	0.980cd	**0.985cd**
T7	Sw+B	0.953bc	0.963cd	**0.958 de**
T8	Sw+B+K	1.200a	1.213 a	**1.207a**

*** Note similar characters within the single column indicate no significant differences between them.**

Calcium content in leaves: Table 4 shows that treatment T8 (2.015%) outperformed the others followed by T4 (2.100%) with T1 (1.570%) registering the lowest value in the first year. Treatments T8 (2.240%) and T4 (2.200%) outperformed the others in year 2 while the lowest value was for the control (1.600%). The highest averages for the two years were for treatments T8 (2.128%) and T4 (2.150%) and the lowest in the control (1.585%).

Table 4: Effect of foliar fertilization with nutrients and seaweed extract on calcium content in leaves.

		Leaf Calcium Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	1.570e	1.600e	**1.585e**
T2	K	1.880d	1.992d	**.1.936d**
T3	B	2.040bc	1.993c	**2.017c**
T4	SW	2.100ab	2.200a	**2.150a**
T5	B+K	1.903 d	1.983 c	**1.943dc**
T6	Sw+K	1.870d	1.933cd	**1.902d**
T7	Sw+B	2.013 c	2.130b	**2.072b**
T8	Sw+B+K	2.015a	2.240a	**2.128a**

*** Note similar characters within the single column indicate no significant differences between them.**

Leaf magnesium content: Table 5 shows that treatments T5 (0.550%) and T3 (0.550%) led the others although there were no significant differences between the treatments, except for the control which had the lowest value (0.480%) in the first year. In the second year, treatments T8 (0.553%) and T3 (0.553%) outperformed the others while the highest average value for both years was for T3 (0.551%), significantly outperforming the others. The lowest value was for treatment T1 (0.490%).

Table 5: Effect of foliar fertilization with nutrients and seaweed extract on magnesium content in leaves.

		Leaf Magnesium Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	0.480b	0.500b	**0.490b**
T2	K	0.523ab	0.510ab	**0.516ab**
T3	B	0.550a	0.553a	**0.551a**
T4	SW	0.530ab	0.500b	**0.515ab**
T5	B+K	0.550a	0.530ab	**0.540ab**
T6	Sw+K	0.496ab	0.523ab	**0.509ab**
T7	Sw+B	0.496ab	0.500b	**0.498b**
T8	Sw+B+K	0.503ab	0.553a	**0.528ab**

*** Note similar characters within the single column indicate no significant differences between them.**

Content of boron in leaves: Table 6 shows that for year 1, treatment T8 (46.10%) outperformed others. Clear significant differences were seen between the treatments, while the lowest value was for T1 (34.90%). In year 2, the highest value was for T8 (46.32%) and the lowest in the control (35.42%). For the two-year average, T8 at 46.12% outperformed the other treatments.

Table 6: Effect of foliar fertilization with nutrients and seaweed extract on boron content in leaves.

		Leaf Boron Content (%)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	34.90 g	35.42g	**35.16i**
T2	K	37.61 f	37.92 f	**37.77 g**
T3	B	41.91c	42.35 c	**42.13 c**
T4	SW	44.12b	44.01b	**44.07b**
T5	B+K	41.00d	41.12d	**41.06d**
T6	Sw+K	38.12e	38.40e	**38.26e**
T7	Sw+B	38.01e	37.97f	**37.99 f**
T8	Sw+B+K	46.10a	46.32a	**46.21a**

*** Note similar characters within the single column indicate no significant differences between them.**

The average nitrogen content in leaves for the control over the two years was low at 1.63% and in some treatments reached normal position.

Paper spraying with algae increased the ratio of nitrogen, phosphorus, potassium, and magnesium in leaves (6). This increase may be due to the nutrient content in marine algae, especially nitrogen, phosphorus and potassium, as well as micro-elements which are quickly absorbed by leaf-spraying as well as the algae's ability to increase nitrogen absorption efficiency (19). These results are consistent with (4) on apricots and (5) on olives where marine algae produced the highest nitrogen and potassium content in the leaves, respectively. (22) added that the spraying of marine algae extract regardless of its type increased the ratio of nitrogen, phosphorus, and iron in leaves.

The use of potassium sulfate (2%) led to a significant increase in potassium and nitrogen ratios, but had no effect on those of phosphorus and calcium, while having a limited effect on boron compared to the control (21). This may be attributed to the role of potassium in stimulating enzymes to manufacture protein and amino acids. (26) noted that spraying mango trees with various forms of potassium had a positive effect on the mineral content of the leaves. The application of potassium sulfate and potassium chloride also increased the nitrogen, phosphorus, and potassium content in apple-tree leaves. (11) found that boron spraying had a clear effect on improving the nutritional status of the cherry tree. Note (8).

The application of boric acid increased phosphorus and calcium content in the leaves but found (10) low potassium content with the application of boron. Boron application increased the nitrogen, phosphorus, calcium, and magnesium content in apple leaves but not potassium (29). (12) also reported that paper spraying of boron on olive trees had a positive impact on the content of potassium, phosphorus, nitrogen, zinc, and boron in the leaves.

Leaf content of chlorophyll A: Table 7 shows that the T5 treatment results at 2.21 mg/g outperformed the other treatments with a clear significant difference between them in the first year. This was replicated in year 2 with T5 producing 2.24 mg/g, and the control recording the lowest value at 1.24 mg/g. In terms of the two-year average, T5 (2.22 mg/g) significantly outperformed the other treatments, and the control registering the lowest value at 1.29 mg/g.

Table 7: Effect of foliar fertilization with nutrients and seaweed extract on chlorophyll A content in leaves.

		Chlorophyll A (mg/g)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	1.34h	1.24h	**1.29h**
T2	K	1.38f	1.34f	**1.36f**
T3	B	1.89c	2.01c	**1.95c**
T4	SW	1.69e	1.76e	**1.72e**
T5	B+K	2.21a	2.24a	**2.22a**
T6	Sw+K	1.71d	1.88d	**1.79d**
T7	Sw+B	1.36h	1.26g	**1.31g**
T8	Sw+B+K	1.96b	2.03b	**1.99b**

*** Note similar characters within the single column indicate no significant differences between them.**

Paper content of chlorophyll B: Table 8 indicates that the 2.15 mg/g output in the T4 treatment exceeded the others in the first year, with the lowest value for the control (1.33 mg/g). It also outperformed the other treatments, at 2.46 mg/g, in the second year. The two-year averages recorded significant differences between treatments with T4 (2.30 mg/g) outperforming the others, and the control recording the lowest values at 1.41 mg/g.

Table 8: Effect of foliar fertilization with nutrients and seaweed extract on chlorophyll B content in leaves.

		Chlorophyll B (mg/g)		
Transaction No	**Treatment**	**2021**	**2022**	**Two-year average**
T1	Control	1.33h	1.49f	**1.41g**
T2	K	2.02c	2.00c	**2.01d**
T3	B	2.07c	2.05c	**2.06c**
T4	SW	2.15a	2.46a	**2.30a**
T5	B+K	2.04d	2.02c	**2.03cd**
T6	Sw+K	1.54g	1.58e	**1.56f**
T7	Sw+B	1.92f	1.71d	**1.81e**
T8	Sw+B+K	2.12b	2.20b	**2.16b**

*** Note similar characters within the single column indicates no significant differences between them.**

Leaf content of total chlorophyll: Figure 1 shows the superiority of treatment T5 (4.25 mg/g) and the significant differences between treatments. The lowest values were in treatment T1 (2.67 mg/g) in year 1, while in the second year, the highest values were in treatment T5 (4.26 mg/g) and the lowest in T1 (2.73 mg/g). The average for the two years shows T5 (4.25 mg/g) and T8 (4.15 mg/g) outperforming the others, with the lowest value in the control treatment (2.70 mg/g).

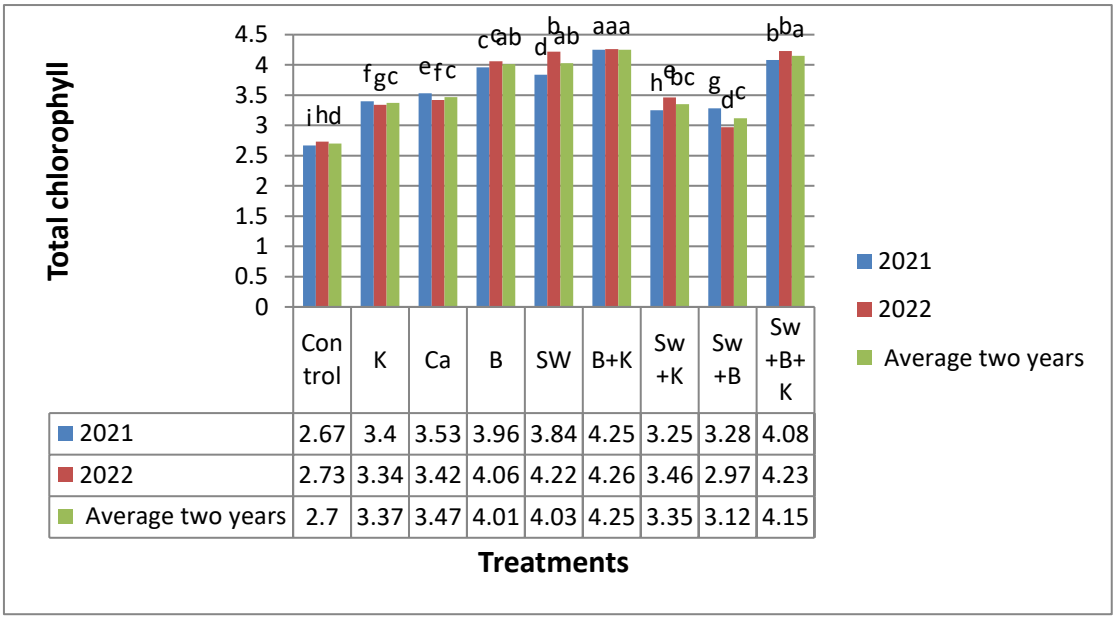

Figure 1: Different treatments and total leaf chlorophyll content.

Marine algae extracts contain nutrients that increase the plant's metabolic activities. They include potassium which is essential for activating enzymes for the manufacture of amino acids and protein, as well as aid in manufacturing the chlorophyll required for photosynthesis. They also increase the amount of carbohydrates produced in leaves of trees that tend to fruit, thereby increasing productivity (20).

Marine algae activate the photosynthesis process and increase the chlorophyll content in the leaves. They also increase leaf area and enhance the efficiency of the photosynthesis process (2) as well as inhibit chlorophyll degradation due to the

enzymes in them (7). Marine algae extracts contain cytokinins have an important role in delaying the aging of leaves by reducing chlorophyll degradation. As stated by (31) applying algae extract to leaves increases cell membrane permeability and improves the ability of plants to absorb mineral elements, such as nitrogen and phosphorus directly associated with chlorophyll formation in plant leaves. (22) noted that spraying the Golden Delicious apple trees with marine algae extract increased the chlorophyll content in the leaves, similar to that for Ibrahimi apple leaves (14).

The increase in leaf chlorophyll content can be attributed to the high micronutrient content found in marine algae extract. Nitrogen has an important role in the formation of chlorophyll, with 70% of it in the leaves contributing to the process leading to improved photosynthesis rates (3). Potassium helps increase various physiological processes, including the manufacture of chlorophyll (23) while boron improves the health of leaves and the absorption of other nutrients (15). It also reported that the application of boric acid at 0.05% to Valencia orange trees improved leaf areas and their content of chlorophyll A, chlorophyll B, and total chlorophyll. The paper application of boron to olive trees was effective in improving the level of chlorophyll in leaves (12).

Conclusions

The mixed use of potassium, boron, and marine algae extract on Golden Delicious apple trees had a positive effect on the content of nutrients and chlorophyll in the leaves. It is recommended to paper spray the trees with a combination of concentrated potassium (2.5g/liter), boron concentration (340ppm), and concentrated marine algae extract (0.5g/liter). This should be done thrice during the growing season, at the appropriate stages for the needs of the trees for the different nutrients (red turbot stage, nodal stage, higher than the Rovil leaf in the decade).

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Author 1: review and editing. The authors have read and approved the published version.

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Data available upon request.

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The authors declare no conflict of interest.

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