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Communication

The Response of Chlorophyll Content and Ionic Composition in Tomato and Pepper Seedlings to Foliar Nutrition in Growing Chambers

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Abstract: Studies have shown that applying specific solutions to the leaves of tomato and pepper plants can boost their output by enhancing nutrient absorption. The factorial analysis of two factors was used in data collection and statistical analysis in this experiment. The first factor was the cultivar (Mobil, Korall, and Tyking F1 for tomatoes, and while cultivars of Carma, Fokusz, and Bobita F1 for sweet pepper), and the second was the spray treatment. Sprays used were sodium bicarbonate (0.52%), 50 mg·L^{-1} salicylic acid, and distilled water. The parameters collected were the SPAD index of chlorophyll and the plant sap's content of calcium, potassium, and nitrates, with five observations for each record. Salicylic acid 50 mg·L^{-1} caused the highest multiple contents, particularly in the tomato cultivar Korall. The lowest multiple contents were for the Mobil cultivar. Spraying Mobil with salicylic acid (50 mg·L^{-1}) and sodium bicarbonate (0.52%) produced the lowest chlorophyll and ionic content. Salicylic acid 50 mg·L^{-1} also led to the highest multiple values, particularly in the Carma pepper cultivar. The results revealed the multiple lowest contents of measured parameters were for the Bobita F1 cultivar. Finally, gardeners should consider growing Korall tomato and Carma pepper with a supportive spraying application of salicylic acid 50 mg·L^{-1} before seedlings are transferred to an open-air garden. Gardeners should consider the additional production-improving aspects described in existing research and seed manufacturer recommendations.

Keywords: abiotic stress; organic gardening; plant health; salicylic acid; SPAD index

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1. Introduction

The physiological reactions and capacity for stress tolerance of a species significantly impact the chlorophyll content [1]. The chlorophyll content is one of the most crucial indicators for determining drought tolerance in tomatoes [1]. Due to metabolic instability caused by drought stress, the amount of chlorophyll in the leaf changes, which lowers light absorption [2]. The overall quantity of photosynthetic pigments in leaves determines the amount of light they absorb [2]. Photosynthesis uses photosynthetic pigments in the photochemical photosystems (PSI, PSII) of leaves to absorb light and transform it into chemical energy [2]. It is possible to anticipate a decrease in photosynthesis and chlorophyll content under drought-stress circumstances [2]. Drought stress is one of the most severe abiotic stresses that plants face because it reduces the flow of essential nutrients to the root zone and limits water accessibility to cells due to insufficient hydraulic conductance from roots to leaves, caused by stomatal closure. The reduced hydraulic conductivity leads to a decrease in nutrient supply to the shoot [2].

Foliar feeding is a yield-enhancing corn production technique involving measuring chlorophyll content [3]. The rates of liquid organic fertilizer and nitrogen uptake by sweet corn increase through foliar application, but the uptake of phosphorus and potassium does not [4]. Foliar nutrition through chlorophyll content measuring will contribute greatly to the improvement of plant health if the reverse relationship between dehydration and nutrient uptake is resolved.

The resistance of plant leaves to foliar urea treatment varies depending on the plant [5], as cited in [6]. However, pepper and tomato foliage resistances are similar (0.48–0.72 Kg of urea sprays in 100 L^{-1} of water). To achieve optimal growth, yield, and quality of peppers and tomatoes, a gardener can apply magnesium sulfate hydrate (epsomite) through foliar spraying [7]. Supplemental foliar potassium application reduces fruit weight loss and decay while increasing the total soluble content in long sweet pepper; the most efficient sources are potassium sulfate (K_2SO_4) and potassium chloride salt (KCl) [8]. The most effective source of increased total phenols is K_2SO_4. When potassium is provided in the form of potassium salt (KCl), it increases the total sugar and vitamin C levels in fruits. The amount of nitrogen and phosphorus in the fruit increases after KCl salt treatments [8]. In Zlaten Medal pepper plants there is a relationship between nitrogen and plant vegetative growth. Five-day-old pepper seedlings are hydroponically cultivated using a nutrient solution without nitrogen. The lack of nitrogen in the medium results in a decrease in leaf area and accumulation of plant biomass, as well as an increase in the root shoot's dry weight ratio. The photosynthetic activity and chlorophyll of pepper plants significantly decrease when there is a depletion of nitrogen. This is because nitrogen is crucial for the development of the chloroplast structure, which affects the productivity and strength of photosynthesis [9]. The direct connection between physiological traits relates to photosynthesis, vegetative growth, pepper plant production, and nitrogen. The health of vegetative development reflects the health of the fruit, growth, and production in general since the leaves are the biological factory that feeds the growth of the pepper fruits.

After spraying two types of organic acids (Biomin followed by Humifolin) on the leaves, there is an increase in chili pepper leaf area, leaf number, chlorophyll index, and nitrogen, potassium, and calcium concentrations [10]. The salinity levels are 3000 and 6000 $mg \cdot L^{-1}$, whereas tap water has a salinity level of 300 $mg \cdot L^{-1}$. Irrigation with highly concentrated salt water decreases plant height and biomass output, compared to irrigation with tap water. When compared with plants subjected to moderate salt irrigation (3000 $mg \cdot L^{-1}$), plants subjected to extreme salinity irrigation (6000 $mg \cdot L^{-1}$) show the most detrimental effects. Thus, 200 $mg \cdot L^{-1}$ of potassium monophosphate (KMP) applied topically through leaves improves biomass production and plant development [11]. Exogenous Alpha-Tocopherol (TOC) foliar spraying increases chlorophyll, enzymatic and non-enzymatic antioxidants, plant development, and salt stress tolerance in pepper plants, enhancing their ability to adjust to soil salinity issues. This may be a result of the staying-green effect mediated by cytokinin. The results of this study show that pepper plants may tolerate salt stress better when exogenous spraying of TOC at a concentration of 1 $mmol \cdot L^{-1}$ boosts the expression of stress response genes [12]. When sweet pepper plants experience salt stress from sodium chloride (NaCl), applying a foliar silicon spray increases the levels of chlorophylls (a and b), mineral nutrients, and moisture status [13]. In conclusion, foliar nutrition is closely linked with increasing pepper vegetative growth indicators (such as chlorophyll content) under environmental stress.

When a solution of calcium chloride ($^{45}CaCl_2$) is sprayed onto the basal and apical leaves of chili pepper, only a small amount of calcium (^{45}Ca) is transported to nearby tissues [14]. The direct application of repeated calcium spray doses to growing fruit organs may therefore be the most efficient calcium fertilization technique for raising calcium concentrations in chili fruits [14]. Different calcium formulations, including calcium nitrate from $Ca(NO_3)_2$, Insol calcium, and Librel calcium, are utilized in the foliar feeding of sweet pepper plants [15]. After applying $Ca(NO_3)_2$, higher concentrations of potassium are found compared to the control. The application of Insol calcium also stimulates an increase in potassium content. Moreover, feeding with a Librel calcium type results in the discovery of more potassium in the fruit. The content of phosphorus is lower following the application of both Insol calcium and Librel calcium. Fruits' average calcium content increases by 25.3% after five treatments, and 15.3% after only three treatments, compared to the control [15]. Before harvest, foliar applications of 0.3% or 0.5% calcium chloride ($CaCl_2$) improve red sweet pepper's storage quality [16]. Fruits treated with $CaCl_2$ before harvest experience a decrease in C_2H_4 generation and respiration rates throughout storage at 7 °C. The ascorbic acid level in the cells increases as a result of the $CaCl_2$ treatment [16]. These findings suggest that various forms of calcium foliar nutrition on pepper plants may influence the ionic composition of leaves (such as potassium content), crop yield quality, and plant vegetative growth.

All potassium humate, potassium chloride, and especially potassium sulfate (K_2SO_4) foliar potassium (K) sources improve the photosynthetic process, pepper plant biomass, chlorophylls (a and b), and endogenous macronutrients (NPK) [17]. However, plant treatment with iron sulfate ($FeSO_4$) produces the highest vegetative growth indices; foliar iron (Fe) treatment improves total pepper growth significantly. Control plants record the lowest chlorophyll content, whereas $FeSO_4$ gives the highest soil plant analysis development (SPAD) index values of young and old leaves [18]. Chitosan foliar treatment on chili peppers causes plants to grow faster than control plants in terms of height, leaf number increments, and chlorophyll content [19]. The foliar nutrition of pepper plants with potassium-containing solutions may impact the chlorophyll content of leaves as well as key nutrients like nitrogen and phosphorus. These studies suggest that foliar iron supplementation may provide similar benefits.

Salicylic acid promotes stress tolerance by improving the tomato plant's physiological response to salt and temperature extremes, as well as by altering antioxidant, nutrient, and chlorophyll levels when applied exogenously as a foliar spray [20]. Using a copper-based foliar fertilizer with added zinc in conjunction with controlled-release urea can increase tomato plant growth based on a single year's data. Tomato plants sprayed with copper foliar fertilizer and zinc (CFF + Zn) grow taller and have more chlorophyll in their leaves than water-sprayed plants [21]. However, foliar zinc application at a low dose (23 $mg \cdot L^{-1}$) alleviates zinc deficiency in tomatoes while increasing dry matter and chlorophyll content [22]. In the same study, foliar zinc (Zn) treatment at high concentrations (230 $mg \cdot L^{-1}$) resulted in lower dry matter and chlorophyll content. After applying additional potassium and phosphorus (K and P) to the leaves, three cultivars of tomatoes showed an increase in dry matter and chlorophyll concentrations. Plants growing with high sodium chloride (NaCl) levels will have insufficient phosphorus and potassium concentrations, and supplemental delivery via leaves remedies this [23]. Consequently, tomato growth and chlorophyll content results are stimulated by different foliar nutrition trials.

Tomato plants' xylem tissue synthesis during fruit development may be impacted by a calcium deficiency coupled with reduced sap flow brought on by a water shortage [24]. This prevents the xylem from transporting calcium into the fruit, which may lead to blossom-end rot [24]. On the other hand, healthy fruits deliver more soluble calcium than fruits displaying this physiological problem [24]. Furthermore, foliar calcium application is required for tomato resistance to bacterial wilt [25] and fusarium crown rot [26]. Foliar phosphorus treatment in greenhouse tomatoes increases chlorophyll, potassium, phosphorus, magnesium, and iron concentrations in the leaves, accelerating fruit maturity and increasing marketable production and quality [27,28]. Another study found that spraying tomato plants with different calcium salt combinations reduces powdery mildew (*Erysiphe orontii*) colony counts on leaves as effectively as elemental sulfur. Powdery mildew development in tomatoes is reduced by foliar calcium treatment due to both osmotic (concentration) and ion-specific effects [29]. Furthermore, higher calcium availability boosts tomato resistance to *Ralstonia solanacearum*-caused bacterial wilt, while highly resistant cultivars have high calcium absorption [30]. Foliar calcium nitrate (117 $mg \cdot kg^{-1}$ nitrogen and 166 $mg \cdot kg^{-1}$ calcium) and Multifeed (Plaaskem (Pty) Ltd., South Africa), applyed every second week at the indicated application rate of 1 $g \cdot L^{-1}$ in an open-bag hydroponic system, increases the mineral content of tomato fruits (potassium, phosphorus, magnesium, and zinc), as well as the calcium content and total soluble solids of cherry tomatoes [31]. Tomato crops fertilized via leaves with 6 mmol·L^{-1} calcium nitrate and 4 mmol·L^{-1} potassium phosphate had higher quality [32].

Another study found that foliar feeding a mixture of calcium, boron, zinc, and copper (100 mg·L^{-1} each) with molybdenum (50 mg·L^{-1}) nutrients results in a significant increase in tomato plant height, branches per plant, fruit set, fruits per plant, fruit weight, yield, shelf life, lycopene content, and ascorbic acid when compared to treatments with Ca, B, Zn, Mo, Cu alone, or multiplex without calcium [33]. Through research, it has been shown that applying calcium silicate at a 1% concentration to the leaves of tomato plants results in improved quality parameters such as increased levels of lycopene and titrable acidity. On the other hand, applying potassium silicate at the same concentration increases the number of flowers, fruits, and yield per plant. Additionally, applying potassium sulfate at a 1% concentration leads to an increase in fruit weight [34]. In summary, foliar feeding of calcium is crucial to tomatoes' growth and plant health.

This study predicted that drought-tolerant tomato and sweet pepper cultivars might not require a dose of salicylic acid or sodium bicarbonate foliar nutrition before being transferred to open-air gardens. The study determined a plant's health condition when sprayed with 4 mL of each organic solution on true leaf seedlings growing in an ideal simulated environment for tomatoes and peppers. This experiment explored how drought-tolerant and non-drought-tolerant varieties of the two crops respond to treatments by measuring aspects of the plant's biochemical composition.

2. Materials and Methods

Three tomato cultivars (Mobil, Korall, and Tyking F1) and three sweet pepper cultivars (Carma, Fokusz, and Bobita F1) were planted in a nursery in Debrecen (Hungary) under ideal and controlled environmental conditions. Fifty seeds of each cultivar were planted in fifty-six cells of a half-plastic emergence tray, with the seeds distributed across eight rows and seven columns. Two of the six cultivars mentioned were planted in each tray, which was 46 cm long and 28 cm wide.

After emergence, the trays were removed from the nursery, where the tomatoes were in the stage of the second true leaf set and the sweet peppers were in the stage of the first true leaf set. The three trays were placed in a growth incubator PHCBI Model, MLR-352-PE, (Panasonic Healthcare Company, Sakata, Oizumi, Ora-Gun, Gunma, Japan). The temperature was set to 25 °C. For lighting, three fluorescent lamps were placed (right, left, and opposite the seedlings), each with a power of 37 watts. The lights were turned on for 10 h a day (from 8 a.m. to 6 p.m.), then turned off automatically for the 14 h the remainder of the day. The relative humidity was raised to 80% using a bucket of water with a capacity of six liters of tap water (monitored using a sensor, Extech 445702, Nashua, NH, USA).

On day 24 of planting, a Konica-Minolta company SPAD index meter tool was used to estimate chlorophyll content (SPAD-502Plus, Konica-Minolta Company, Osaka, Japan). Five plants from each cultivar were chosen at random, and five chlorophyll estimates were collected at random for each plant, with the average record reported. Each record was collected from the upper half of the leaf.

Each cultivar received a spraying treatment on the 38th day after planting. The following solutions were applied at a rate of 4 mL to each plant: 0.52% sodium bicarbonate was sprayed on every 2 rows of seedlings of each plant cultivar; a spray solution of 50 mg·L^{-1} salicylic acid was sprayed on the other two rows of each cultivar seedlings, and distilled water was sprayed on each seedling's cultivar for the two plants in the last two rows of a tray. Two days after spraying, a SPAD index meter was used to record five estimations for each plant from each treatment. Similarly, after 8 days of spraying, another chlorophyll content record was taken.

The roots of ten normal plants from each treatment were cleaned and dried 40 days after transplantation (58 days after planting). All parts of the ten seedlings were crushed in a blender (SENCOR model) for three minutes. The mixture was pressed in a garlic press to extract plant sap. A total of five samples were collected. The calcium cation

(Ca^{2+}), potassium cation (K^+), and nitrate (NO_3^-) contents (mg·L^{-1}) in the plant sap were measured using three electronic sensors of the type HORIBA LAQUA-TWIN instruments, (Advanced Techno Company, Kyoto, Japan) where five readings were taken for each ion, cultivar, and treatment. Before use, sensors were calibrated twice with standard solutions (150 and 2000 ppm, or mg·L^{-1}). A similar procedure was conducted for the organic spray solutions.

The acidity of the organic spray solutions of [salicylic acid ($C_7H_6O_3$) 50 mg·L^{-1}, sodium bicarbonate ($NaHCO_3$ 0.52%), and distilled water (H_2O)] was tested using an acidity tester (pH meter model: VWR PH/CO 1030), and four replicates were taken. There were no additives used in the preparation of the raw solutions. To calibrate the acidity of the digital device before each use, the following chemical buffers were used: 4.01, 7, and 10.01. After every measurement, the sensor was cleaned with distilled water and dried.

The percentage of emergence was calculated when the seedlings were transferred from the nursery to the growth incubator. Every ten seeds were counted as a replicate (ANOVA 1-factor of cultivar), with five replicates for each cultivar. Similar to the preceding parameter, five replicates (plants) were chosen at random for each cultivar to obtain their SPAD index and statistics (ANOVA 1-factor of cultivar). The two parameters were considered for the cultivars, which were arranged as a completely randomized design (CRD). After foliar nutrition, the data were collected and analyzed using a factorial analysis 2-Way ANOVA of two factors, with the first factor being the cultivar and the second factor being the spray treatment, and each record having five observations. Finally, at a probability level of 0.05, means were separated using the honestly significant difference method (HSD). The post hoc test (Tukey–Kramer post hoc test in Minitab 20) was used to assess gaps in the means of different groups. Further, Minitab 20's regression response optimizer was used to determine the maximum and minimum responses to each plant's calcium, potassium, nitrate, and SPAD index variables, with only cultivar and foliar nutrition factors considered (cultivar and foliar nutrition interactions were discarded due to weak interactions).

3. Results

Each tomato and sweet pepper cultivar's emergence percentage is presented in Table 1. The emergence percentage of the cultivar Tyking F1 was significantly the lowest (86%). Sweet pepper cultivars showed no significant differences. Before foliar spraying, the SAPD index of tomatoes and sweet peppers showed no significant differences between cultivars. In terms of the SPAD index, the drought-tolerant cultivar (Mobil) outperformed the others. Although Carma and Fokusz had a higher SPAD index than the non-drought-tolerant pepper (Bobita F1), there were no significant differences between them (Table 1).

Table 1. Impact of tomato and sweet pepper cultivars on the emergence (%) and the SPAD index before foliar nutrition.

Parameter	Emergence (%)	SPAD Index
Tomato cultivars		
Mobil	98 a	26.38 a
Korall	92 ab	20.14 a
Tyking F1	86 b	19.82 a
Sweet pepper cultivars		
Carma	90 a	27.94 a
Fokusz	90 a	26.50 a
Bobita F1	88 a	25.46 a

Means in columns sharing the same letters are not significant at the 5% HSD probability level.

There was no significant interaction between the effects of plant cultivar and foliar nutrition treatment on the SPAD index after two and eight days of foliar nutrition. Tomato foliar nutrition had greatly increased for Tyking F1 after 48 h and eight days (Table 2). The Tyking F1 tomatoes' SPAD index was significantly higher than those of the other tomato cultivars after eight days. Mobil and Korall cultivars were not significantly different (Table 2). However, there were no significant differences between tomato cultivars and sweet pepper cultivars after two days (Table 2). Pepper foliar nutrition increased chlorophyll content slightly in all cultivars, noticeably after eight days (Table 2), without any significant differences between cultivars. In tomatoes, this might be due to the sodium bicarbonate solution's primary effect on the non-drought-tolerant tomato cultivar (Tyking F1).

Table 2. Impact of tomato and sweet pepper cultivars on the SPAD index and ionic composition (Ca^{2+}, K^{+}, and NO_3^{-}) after foliar nutrition.

Parameter	SPAD Index (48 h)	SPAD Index (Eight Days)	Calcium Content (Ca^{2+}) ($mg \cdot L^{-1}$)	Potassium Content (K^{+}) ($mg \cdot L^{-1}$)	Nitrate Content (NO_3^{-}) ($mg \cdot L^{-1}$)
Tomato cultivars					
Mobil	24.07 a	28.38 b	1042.7 a	1175.3 b	222.67 a
Korall	24.91 a	25.80 b	787.33 c	1346.7 a	183.33 b
Tyking F1	28.41 a	32.50 a	845.33 b	1380 a	233.33 a
Sweet pepper cultivars					
Carma	27.21 a	31.85 a	1342 a	1892.7 a	575.33 b
Fokusz	28.66 a	33.13 a	1080 a	2252.7 a	1061.33 a
Bobita F1	25.89 a	28.23 a	320 b	2546.7 a	680.67 ab

Means in columns sharing the same letters are not significant at the 5% HSD probability level.

For tomatoes' calcium cation content (Ca^{2+}), the interaction between cultivar and foliar nutrition treatment was not significant. Among foliar nutrition treatments, for tomatos, Mobil had a significantly higher calcium cation content ($mg \cdot L^{-1}$) than both the Korall and Tyking F1 cultivars (Table 2). There was a significant interaction between cultivar and foliar treatment for calcium cation content in sweet peppers (Figure 1). Also, there was a significant interaction between cultivar and foliar treatment for potassium cation content in tomatoes (Figure 2). For potassium cation content, no significant interactions were found between the sweet pepper cultivar and foliar treatment. There were no significant differences between sweet pepper cultivars with regard to potassium content (Table 2).

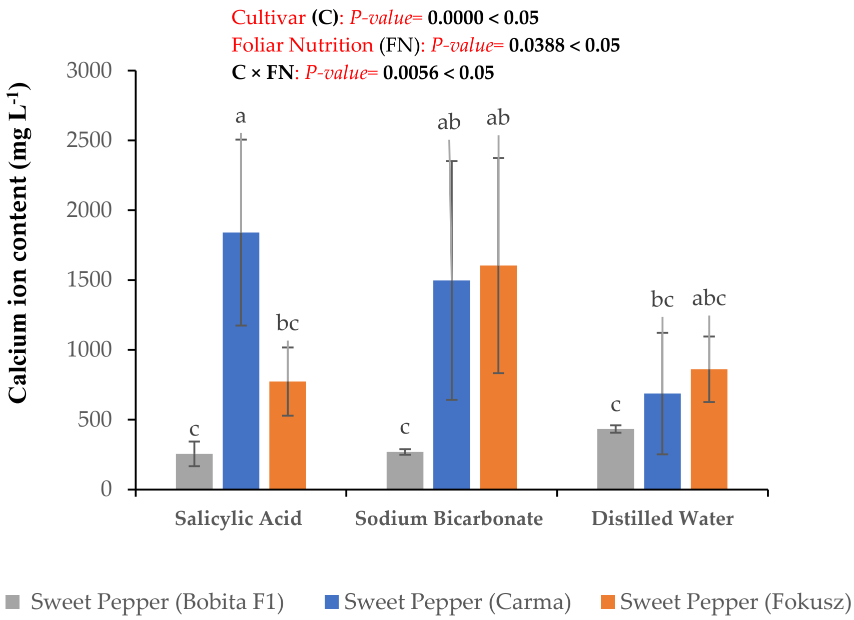

Figure 1. Mean values for calcium cation content ($mg \cdot L^{-1}$) combined for three sweet pepper cultivars and three foliar nutrition treatments, (±) bars (standard error) customized around standard deviation values. Means sharing the same letters are not significant at the 5% HSD probability level.

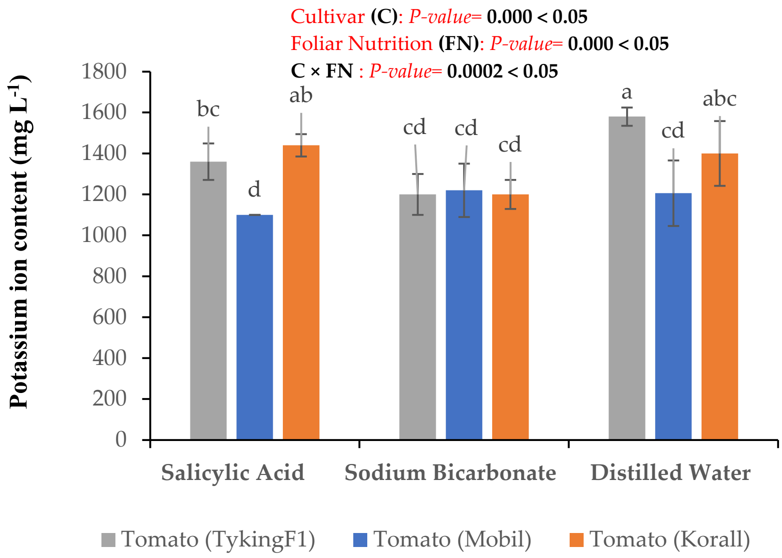

Figure 2. Mean values for potassium cation content (mg·L^{-1}) combined for three tomato cultivars and three foliar nutrition treatments, (±) bars (standard error) customized around standard deviation values. Means sharing the same letters are not significant at the 5% HSD probability level.

The interactive relationship between tomato cultivar and foliar nutrition treatment was not significant for nitrate content parameters. Among the foliar nutrition treatments, both tomato cultivars (Mobil and Tyking F1) had significantly higher plant sap nitrate content (mg·L^{-1}) than the Korall cultivar (Table 2). The interactive relationship between cultivar and foliar nutrition treatment for nitrate levels in sweet pepper was also not significant. The Fokusz sweet pepper cultivar had significantly higher plant sap nitrate content (mg·L^{-1}) than the Carma cultivar with regard to foliar nutrition treatments (Table 2). When compared to the other cultivars, the Bobita F1 cultivar had a non-significant difference and the lowest nitrate content.

Among tomato cultivars, the sodium bicarbonate (0.52%) treatment had a significantly higher SPAD index (after 48 h of spraying, and after eight days of spraying) than the salicylic acid and distilled water treatments (Table 3). There was a significant difference among sweet pepper cultivars between sodium bicarbonate treatment (0.52%) and distilled water treatment (Table 3). Sodium bicarbonate (0.52%) and salicylic acid (50 mg·L^{-1}) treatments also recorded a significantly higher SPAD index than the distilled water treatment for sweet pepper cultivars after eight days (Table 3).

Table 3. The overall mean for the effect of foliar nutrition on SPAD index and ionic composition (Ca^{2+}, K^+, and NO_3^-) among tomato and sweet pepper cultivars.

Parameter	SPAD Index (48 h)	SPAD Index (Eight Days)	Calcium Content (Ca^{2+}) (mg·L^{-1})	Potassium Content (K^+) (mg·L^{-1})	Nitrate Content (NO_3^-) (mg·L^{-1})
Foliar nutrition for tomato cultivars					
Salicylic Acid 50 mg·L^{-1}	23.85 b	28.34 b	955 a	1300 b	214.67 a
Sodium Bicarbonate 0.52%	31.02 a	32.23 a	770 b	1206.7 c	213.33 a
Distilled Water	22.51 b	26.10 b	950 a	1395.3 a	211.33 a
Foliar nutrition for sweet pepper cultivars					
Salicylic Acid 50 mg·L^{-1}	27.5 ab	34.29 a	956.7 ab	2413.3 a	755.33 a
Sodium Bicarbonate 0.52%	31.21 a	35.35 a	1124 a	2430.7 a	849.33 a
Distilled Water	23.05 b	23.57 b	661.3 b	1848.0 a	712.67 a

Means in columns sharing the same letters are not significant at the 5% HSD probability level.

Foliar nutrition treatments did not differ in calcium cation content for all tomato cultivars except for sodium bicarbonate, which had the lowest significant calcium cation content (mg·L^{-1}) of the tomato cultivars (Table 3). The lowest significant calcium content among sweet pepper cultivars was for distilled water spray treatments, without any significant differences between salicylic acid (50 mg·L^{-1}) and sodium bicarbonate (0.52%) (Table 3).

For potassium cation content in tomatoes, there was a significant interaction between cultivar and foliar treatment (Figure 2). No significant differences were recorded in potassium content between foliar nutrition treatments for the sweet pepper cultivars (Table 3). In terms of the potassium cation content in sweet peppers, there was no significant interaction between cultivar and foliar application (Table 3). Finally, foliar nutrition treatments did not affect the nitrate content (mg·L^{-1}) of any tomato cultivar or sweet pepper cultivar (Table 3).

For calcium cation content in sweet peppers, there was a significant interaction between cultivar and foliar treatment (C × FN) (Figure 1). Two of the nine combinations of three sweet pepper cultivars and three foliar nutrition treatments outperformed the others significantly. The scores of Carma cultivar plants under salicylic acid treatment were higher than those of Fokusz plants under sodium bicarbonate treatment (Figure 1). Sweet pepper Bobita F1 cultivar plants had the lowest scores regardless of treatment (Figure 1).

There was a significant interaction between cultivar and foliar treatment for potassium cation content in tomatoes (C × FN). One of the nine combinations of three tomato cultivars and three foliar nutrition treatments significantly outperformed the others (Figure 2). The Tyking F1 cultivar plants performed well under distilled water spray treatment. Mobil cultivar plants treated with salicylic acid performed the worst (Figure 2).

As shown in Table 4, salicylic acid 50 mg·L^{-1} caused the strongest multiple responses, particularly for the Korall tomato cultivar. The cultivars were coded in the following order: 1: Mobil, 2: Korall, and 3: Tyking F1. The foliar nutrition was coded in the following order: 1: salicylic acid 50 mg·L^{-1}, 2: sodium bicarbonate 0.52%, and 3: distilled water.

Table 4. Multiple maximum response optimization for ionic composition (Ca^{2+}, K^{+}, and NO_3^{-}) and SPAD index (eight days) parameters in tomatoes.

Response	Goal	Lower	Target	Upper	Weight	Importance
Ca^{2+}	Maximum	660.0	1220.0		1	1
K^{+}	Maximum	930.0	1600.0		1	1
NO_3^{-}	Maximum	150.0	350.0		1	1
SPAD eight days	Maximum	18.1	39.9		1	1
		Solution: multiple response prediction				
Solution	Cultivar *	Foliar Nutrition *	Ca^{2+} Fit	K^{+} Fit	NO_3^{-} Fit	SPAD eight days Fit
1	2.43434	1.14141	851.212	1304.19	216.859	30.7459

* 2.4: Korall cultivar, 1.14: Salicylic acid 50 mg·L^{-1}.

Salicylic acid 50 mg·L^{-1}, as shown in Table 5, caused the strongest multiple responses, particularly for the Carma sweet pepper cultivar. The cultivars were coded in the following order: 1: Carma, 2: Fokusz, and 3: Bobita F1. The foliar nutrition was coded as: 1: salicylic acid 50 mg·L^{-1}, 2: sodium bicarbonate 0.52%, and 3: distilled water.

Table 5. Multiple maximum response optimization for ionic composition (Ca^{2+}, K^{+}, and NO_3^-) and SPAD index (eight days) parameters in sweet peppers.

Response	Goal	Lower	Target	Upper	Weight	Importance
Ca^{2+}	Maximum	190.0	2700.0		1	1
K^{+}	Maximum	410.0	5900.0		1	1
NO_3^-	Maximum	140.0	2300.0		1	1
SPAD eight days	Maximum	9.4	49.3		1	1
		Solution: multiple response prediction				
Solution	Cultivar *	Foliar Nutrition *	Ca^{2+} Fit	K^{+} Fit	NO_3^- Fit	SPAD eight days Fit
1	1	1	1572.67	2186.33	741.111	38.2409

* 1: Carma cultivar, 1: Salicylic acid 50 mg·L^{-1}.

The multiple minimum responses for the Mobil cultivar are shown in (Table 6). Spraying the same cultivar with salicylic acid (50 mg·L^{-1}) or sodium bicarbonate (0.52%) produced the lowest chlorophyll and ionic composition results. The results displayed in Table 7 show the multiple minimum responses for the sweet pepper cultivar Bobita F1. When the same cultivar was treated with distilled water, the results of the SPAD index and ionic contents were the lowest.

Table 6. Multiple minimum response optimization for ionic composition (Ca^{2+}, K^{+}, and NO_3^-) and SPAD index (eight days) parameters in tomatoes.

Response	Goal	Lower	Target	Upper	Weight	Importance
Ca^{2+}	Minimum		660.0	1220.0	1	1
K^{+}	Minimum		930.0	1600.0	1	1
NO_3^-	Minimum		150.0	350.0	1	1
SPAD eight days	Minimum		18.1	39.9	1	1
		Solution: multiple response prediction				
Solution	Cultivar *	Foliar Nutrition *	Ca^{2+} Fit	K^{+} Fit	NO_3^- Fit	SPAD eight days Fit
1	1	1.54545	991.657	1176.67	208.535	27.3424

* 1: Mobil cultivar, 1.5: Salicylic acid 50 mg·L^{-1} or sodium bicarbonate 0.52%.

Table 7. Multiple minimum response optimization for ionic composition (Ca^{2+}, K^{+}, and NO_3^-) and SPAD index (eight days) parameters in sweet peppers.

Response	Goal	Lower	Target	Upper	Weight	Importance
Ca^{2+}	Minimum		190.0	2700.0	1	1
K^{+}	Minimum		410.0	5900.0	1	1
NO_3^-	Minimum		140.0	2300.0	1	1
SPAD eight days	Minimum		9.4	49.3	1	1
		Solution: multiple response prediction				
Solution	Cultivar *	Foliar Nutrition *	Ca^{2+} Fit	K^{+} Fit	NO_3^- Fit	SPAD eight days Fit
1	3	3	255.333	2275	803.778	23.8969

* 3: Bobita F1 cultivar, 3: Distilled water.

All raw materials are inexpensive, readily available, and completely impure (Table 8). Distilled water was the primary solvent used in the preparation of all organic solutions. All spray solutions prepared for foliar nutrition testing were basic (alkaline), except for distilled water (neutral). Salicylic acid (50 mg·L^{-1}) had by far the highest content of calcium, while sodium bicarbonate 0.52% had the highest significant content of nitrate (Table 8).

Table 8. The overall mean for the acidity, calcium content (mg·L^{-1}), and nitrate content (mg·L^{-1}) of organic spray solutions.

Raw Material	Major Active Ingredient	Acidity pH of Final Solution ± SEM	Calcium Cation Content (Ca^{2+}) (mg·L^{-1})	Nitrate Ion Content (NO_3^-) (mg·L^{-1})
Salicylic Acid (50 mg·L^{-1})	($C_7H_6O_3$)	7.413 a ± 0.088	16.5 a	6.50 b
Baking Soda (0.52% *w*/*v*)	($NaHCO_3$)	7.63 a ± 0.073	0 c	53.5 a
Distilled Water	(H_2O)	7.023 a ± 0.263	10.25 b	8.50 b

SEM indicates (±) the standard error of the mean (n = 4). Different letters within a cultivar indicate significant differences between groups ($p < 0.05$).

4. Discussion

Based on the regression response optimizer of plant health attributes with regard to chlorophyll and ionic composition, this study assisted global gardeners in selecting the best tomato or sweet pepper cultivar under salicylic acid (50 mg·L^{-1}) foliar nutrition treatment, performed before seedlings are transferred to open-air gardens.

The emergence percentage expresses the viability of the embryo in seeds produced in a nursery or field. In the lab, the standard germination percentage was tested under suboptimal temperature, humidity, and growing media conditions [35]. In the nursery, the emergence percentage represents the typical germination percentage. In general, cultivars that are tolerant to abiotic stress (Mobil, Korall, Carma, and Fokusz) appear to have higher percentages of germination (emergence) in the nursery than others (Table 1).

The species' physiological reactions and stress tolerance significantly impact chlorophyll content. The chlorophyll content is an important indicator for determining drought susceptibility in tomatoes [36]. Because of metabolic instability caused by drought susceptibility, the amount of chlorophyll in the leaf changes, lowering light absorption. Based on existing scientific arguments from [1,2], the tomato cultivar Tyking F1 will have a lower chlorophyll content compared to other tomato cultivars due to its lack of drought resistance (Table 1).

Plant parts above ground are covered by a hydrophobic cuticle, which limits the exchange of water, solutes, and gases between the plant and the atmosphere. However, nutrient solutions can still be absorbed through cracks, stomata, and lenticels [37]. Stomata are important in the absorption of nutrient solutions applied to leaves and foliage. Based on the chemical analysis that is presented in Table 8, the calcium content in both salicylic acids (50 mg·L^{-1}) (16.5 mg·L^{-1}) and distilled water (10.25 mg·L^{-1}) solutions was the highest. The calcium content of salicylic acid (50 mg·L^{-1}) or distilled water may be the cause of Mobil cultivar tomatoes' plant sap calcium excellence (Table 2). Salicylic acid at a concentration of 50 mg·L^{-1} is probably responsible for the elevated calcium levels found in superior cultivars such as Mobil tomatoes and Carma sweet peppers. The considerable calcium content response of the Carma sweet pepper to salicylic acid (50 mg·L^{-1}) foliar nutrition can be observed in Table 2 and Figure 1. The calcium content of plant sap in this experiment supports a previously published hypothesis by Massimi and Radócz [35]. Seedlings were studied under simulated environmental stresses such as non-ideal temperatures, low humidity, close spacing, minimum light dose, nutrient-deficient water, and a lower dosage of salicylic acid (50 mg·L^{-1}) [35]. Two seedling vigor indices were used to assess the seedling's growth. Seedlings of Mobil cultivar tomatoes and Carma cultivar sweet pepper outperform other cultivars, possibly due to the cultivars' vigor under different stress conditions [35]. These findings show that the Mobil cultivar for tomatoes and Carma cultivar for sweet peppers had a positive impact on development and should be raised in nurseries under optimal conditions before being transferred to open-air environmental and biological exposure conditions in Hungary [35]. Spraying Carma seedlings with an appropriate dose of salicylic acid before transplanting improves stress tolerance by improving the plant's physiological response to drought, salt, and temperature extremes, as well as by changing antioxidants and nutrients [35]. Cultivars of Mobil and Carma perform with better vigor than others under suboptimal simulated environmental conditions, and salicylic acid spraying will improve seedlings' vigor.

It is reasonable to conclude that sodium bicarbonate (0.52%) was the primary source of increased chlorophyll content in tomatoes and sweet pepper cultivars (Table 3). The amount of nitrogen in the leaf will increase the chlorophyll content (as measured by the SPAD value) [38]. In comparison to other organic solutions, sodium bicarbonate solution had the highest amount of nitrate (NO_3^-) (53.5 mg·L^{-1}) (Table 8). Nitrate is a nitrogen-rich nitric acid salt that plants can use. Nitrite (NO_2^-) is a nitric acid salt in which nitrogen is not readily available to plants [39]. Sodium bicarbonate spraying during the true leaves stage is a more effective solution for providing nitrate (NO_3^-) to enhance plant health by boosting chlorophyll levels (Table 3). In contrast, salicylic acid, which seems to be the plant growth regulator auxin, has a stimulatory effect that promotes cell elongation. Pectin is formed with the help of calcium. As a result, a lack of this element will result in the collapse of the cell walls. Plant cell walls are composed of pectin, which has an acidic sugar backbone and neutral sugar side chains. It helps with cell adhesion and cell wall formation [40]. As a result, it is possible to deduce that salicylic acid plays an indirect role in cell wall formation during division and elongation. A high temperature increases the relative humidity in the plastic-covered growing facility, influencing transpiration and nutrient transport. Calcium ion uptake is hampered in sweet pepper plants by a long-term root zone temperature of 29 °C [41]. More calcium is required by young pepper plant cells during the fruit-setting stage. This explains the appearance of blossom-end rot. Blossom-end rot is a serious pepper and tomato disease that results from an environmental problem, most commonly uneven watering (drought conditions) and calcium deficiency [39]. Thus, it is worth trying salicylic acid (100 mg·L^{-1}) with a calcium content of 51 mg·L^{-1} in the future in tomato and sweet pepper seedlings' foliar nutrition.

There was no potassium in any of the solutions used on the plants in this experiment. There was no potassium in the distilled water (Table 8). It can be generally concluded that none of the types of spraying affect the potassium content change in tomato and sweet pepper plants' sap. This did not change the fact that non-drought-tolerant cultivars (Tyking F1 and Bobita F1) had the highest potassium levels when compared to the other cultivars; this might be due to the genetic makeup of these cultivars (Table 2). A significant response in the potassium content of tomato (Tyking F1) to distilled water was observed (Table 2 and Figure 2). If diseases or pests are expected because of potassium deficiency, these results may be useful in selecting cultivars. Gray leaf spots, for example, result from a fungus (*Stemphylium solani*) infection that is harmful to pepper plants [42]. This disease in tomatoes and peppers may be caused by a complex combination of potassium deficiency and drought stress. Blotchy ripening of tomatoes is another disorder [39], in which unripe patches of flesh are randomly distributed, and hard, yellow, or green. Dry soil, high temperatures, and a lack of potassium are thought to be major contributors to this disorder [39]. As previously stated, these cultivars (tomato: Tyking F 1 and sweet pepper: Bobita F1) were drought-sensitive, even though they contained potassium in relatively adequate quantities (Table 2). Consequently, relying on these cultivars is fraught with controversy and could be an error.

Nitrite (NO_2^-) is a nitric acid salt with nitrogen which is inaccessible to plants [39]. The SPAD index accurately predicts the total nitrogen content of plant succulents in all forms (NH_4^+, NO_3^-, or NO_2^-). Nitrate content alone cannot adequately describe vegetative growth vigor and chlorophyll content, especially if nitrates convert to amino acid building blocks while the parameters are being recorded. Tomatoes (Mobil and Tyking F1) outperformed Korall in terms of nitrate content (Table 2). This result is consistent with the SPAD index after eight days of foliar spraying, where Mobil and Tyking F1 outperformed the Korall cultivar. After eight days of foliar nutrition, the sweet pepper cultivar Fokusz also had the highest SPAD index, as well as the highest nitrate content (Table 2). Soil microbiologists have previously shown a link between soil acidity and plant nitrate nitrogen availability. In alkaline environments, nitrates are typically more abundant [43]. In Table 8, it can be seen that both salicylic acid (50 mg·L^{-1}) and sodium bicarbonate (0.52%) displayed a slightly basic acidity. Distilled water, on the other hand, had a neutral acidity. Sodium bicarbonate could be the basic organic spraying solution responsible for improving plant sap nitrate content.

Using a regression response optimizer is a compromise or statistical asymptote to eliminate individual comparisons and focus on group comparisons (maximum performance) for general plant health recommendations based on cultivar selection and foliar nutrition treatment. The Korall tomato cultivar thrived when treated with salicylic acid (50 mg·L^{-1}) and outperformed Tyking F1 (Table 4). Spraying the Mobil tomato cultivar with salicylic acid (50 mg·L^{-1}) or sodium bicarbonate (0.52%) produced relatively lower chlorophyll and ionic contents (Table 6). The multiple minimum chlorophyll and ionic compositions were recorded for the Mobil cultivar, which was the cultivar that outperformed in terms of seedling vigor in suboptimal environmental conditions [35]. Growers can grow Mobil without any supportive spraying treatment. However, the Korall cultivar can thrive when planted and treated with salicylic acid (50 mg·L^{-1}) and achieved better performance than Tyking F1 (Table 4). In addition, gardeners should consider growing sweet pepper (Carma) with a supportive spraying application of salicylic acid (50 mg·L^{-1}) (Table 5). The sweet pepper cultivar Bobita F1 produced multiple minimum responses of all plant health status attributes of chlorophyll and ionic contents. The chlorophyll content and ionic composition results were the lowest when this cultivar was treated with distilled water (Table 7). The sweet pepper cultivars were not significantly different in the case of seedlings vigor, despite the sweet pepper cultivar (Carma) having a numerical advantage over the Fokusz and Bobita F1 cultivars in the two examined measures of seedling vigor [35]. In summary, tomato (Korall) and sweet pepper (Carma) will thrive under foliar nutrition with salicylic acid (50 mg·L^{-1}) in the nursery before seedlings are transferred to open-air gardens.

When the active ingredient was added to distilled water in specific amounts, it caused an increase in the levels of nitrates, calcium, or both. However, in some other solutions, these contents may be decreased because of deposition or binding. It is worth noting that the levels of calcium in baking soda decreased to zero (Table 8). In any case, the acidity of each solution varied. Salicylic acid (50 mg·L^{-1}) had the highest calcium cation (mg·L^{-1}) content, while baking soda lacked this (Table 8). It was recorded that the potassium content in all tested solutions was zero. Further, the sodium bicarbonate solution had the highest content of nitrate (mg·L^{-1}) (Table 8). The basic organic spraying solution responsible for improving plant sap nitrate content is sodium bicarbonate, while the organic spraying solution responsible for improving plant sap calcium content is salicylic acid (50 mg·L^{-1}). In general, salicylic acid (50 mg·L^{-1}) produces the maximum health attributes in terms of chlorophyll and ionic compositions.

5. Conclusions

Drought-tolerant tomato cultivars such as Mobil do not require a boost dose of salicylic acid (50 mg·L^{-1}) foliar nutrition in the seedling stage before transfer. Further, the drought-tolerant tomato Korall and the drought-tolerant sweet pepper cultivar Carma require a preventive dose of salicylic acid (50 mg·L^{-1}) foliar spraying before being transferred to the open field. Foliar nutrition is a preventive measure in pest management that improves plant health before environmental and biological stress exposure. Thus, farmers are advised to cultivate sweet peppers (Carma) in nurseries before transferring to the open ground with a salicylic acid (50 mg·L^{-1}) spray once at a rate of 4 mL per seedling. In the nursery, there is no need to spray the Mobil tomato cultivar with either salicylic acid or sodium bicarbonate. If another tomato cultivar (Korall) is chosen, seedlings must be sprayed with salicylic acid (50 mg·L^{-1}) at least once at the same rate before transplanting out of the nursery.

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