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Effect of foliar spraying with Forchlorfenuron on late fruit quality and physio-biochemical indices of fig fruits

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ABSTRACT

Forchlorfenuron (CPPU) is one of the plant growth regulators (PGRs) used to enhance tree yield and quality, as well as to enhance late fig fruit yield and its quality. The aim of this study was to study the influences of CPPU foliar application on growth, physio-biochemical attributes, nutritional homeostasis, and late fruit quality of fig trees under late season conditions (leaf senescence and low temperature). Fig trees sprayed three times with 40.0 µM CPPU showed the best growth (average leaf dry weight and dry matter content), late fruit yield (fruit number branch^{-1} and average fruit weight), and fruit quality traits (contents of fruit total soluble sugars, total soluble solids, and vitamin C) due to enhancements in chlorophyll biosynthesis, relative water content, total soluble sugars, and nutrient balance. These findings recommend the use of three foliar sprays of 40.0 µM CPPU application to promote late fig fruit yield and its quality.

1. Introduction

Fig (*Ficus carica* L.), belonging to the genus and family "Ficus and Moraceae", respectively, is the oldest fruit tree grown all over the world. It is native to Western Asia and is widely distributed throughout the Mediterranean region. In Egypt, figs are second only to Turkey in terms of fresh fig production globally [1]. Figs are rich in mineral nutrients, vitamins, dietary fiber, polyphenols, anthocyanins, carotenoids, and sterols. They also provide a high level of sugar, energy, and healthy bioactive ingredients [2,3]. Fig trees require warm climates [4]. In addition, growing fig trees in semi-arid conditions with scarcity of water is undesirable [5]. Therefore, due to exposing the trees to lower temperatures, the late fruit yield (September–December) becomes less quantity and of lower quality compared to the main fruit yield (June–August). The quantitative and qualitative traits of late fig fruit yield can be noticeably enhanced by using plant growth regulators (PGRs), including cytokinins (CKs) [6]. CKs play roles in delaying leaf senescence, stimulating plant cell expansion and division, fruit setting and enlargement, and increasing crop yields [7].

Forchlorfenuron (N-(2-chloro-4-pyridyl)-N-9-phenylurea; CPPU) is a cytokinin-like compound with potent activity. Roots, flowers, and fruits can absorb CPPU [8], which can delay fruit maturation and fruit ripening of many horticultural crops [9-11]. CPPU can also improve the fruit set, size, and yield. It can minimize fruit spoilage to maintain fruit quality during storage [12]. Using pre-bloom treatment, CPPU can improve fruit sets, while with post-bloom treatment, it can promote fruit color, size, maturity, and quality [9,10]. CPPU treatment exerts virtuous impacts, including limited respiration rate, inhibited natural browning, and retarded fruit maturity and softening [7]. However, the molecular mechanisms belonging to the role of exogenous CPPU treatment in the growth and yield performances of horticultural crops remain not fully understood.

Efforts have been made to study the relationship between ripening, nutrient balance, and fruit quality at the physio-biochemical levels [10,13-16], therefore, this study used foliar spray of CPPU for fig trees to study the relationship between fruit quality and nutrient balance at the physio-biochemical levels. This work aimed to correlate the enhancements of CPPU foliar spray in growth, photosynthesis, nutrient balance, and leaf integrity with late fruit yield and fruit quality traits of fig trees.

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2. Methodology

2.1. The Trial Site and Experimental Duration

A two-season experiment was conducted in the 2019 and 2020 seasons to study the effects of forchlorfenuron (CPPU) on growth, late fruit yield, fruit quality traits, and physio-biochemical attributes of fig trees. The experiments were carried out in the Abdelhady Badr-Eldin farm (29°07'04.5" N 31°04'38.9" E), Bani Sweif, Egypt, in an attempt to improve the quantitative and qualitative traits of late fig fruit yield. Fig trees were planted 4 by 4 m at a density of about 600 trees per hectare. The fig trees identified for each studied season underwent systematic horticultural practices, which were generally followed in the examined farm. A surface irrigation system was followed, and hoeing, and weed and pest management were regularly followed. Analysis of some soil physicochemical properties [17,18] is present in Table 1

Table 1 Physicochemical characteristics of clay loam soil of the experimental orchard (for a depth of 0–45 cm)

Treatments	Season 2019	Season 2020
Sand (%)	28.7	28.7
Silt (%)	20.2	20.2
Clay (%)	51.1	51.1
Texture	Clay loam	
pH	7.69	7.69
ECe (dS m^{-1})	1.82	1.82
Organic matter (%)	1.15	1.15
$CaCO_3$ (%)	2.48	2.46

2.2. Experimental Setup and Treatments

For two seasons, a group of 6-year-old fig trees in 2021 and another group of 7-year-old trees in 2022 were selected for this study. Thirty-six trees were randomly selected uniformly for each season, with 9 trees per treatment. On each tree, 5 random branches were labeled for different evaluations. Each season, the trees were sprayed with 40 µM CPPU only once (CPPU-1-FS, on 15 September), two times (CPPU-2-FSs, on 15 September and 5 October), or three times (CPPU-3-FSs, on 15 September, 5 October, and 25 October). Additionally, control trees were sprayed with distilled water. The spray solutions were supplemented with 0.01% Tween-20 as a surfactant and sprayed early in the morning. Solution volumes of 1.75 and 2 L per tree were sprayed in 2021 and 2022, respectively. Samples for various analyses of growth and physio-biochemical attributes were collected from all treatments on 10 November. Fruit yield components were evaluated throughout the fruiting period of the late fruit yield starting 15 September. Fruit quality traits were assessed 10 days after the foliar spray of CPPU-1-FS treatment, 10 days after the second foliar spray of CPPU-2-FSs treatment, and 10 days after the third foliar spray of CPPU-3-FSs treatment.

2.3. Growth and Fruit Yield-Related Parameters

Average leaf dry matter content (ALDMC, %) was evaluated using the leaf that was allocated to leaf area measurement. After weighing for average fresh weight (ALFW), the leaf was dried in an oven at 70 °C upon reaching a constant weight, and average leaf dry weight (ALDW) was taken. Then, LDMC was calculated as follows:

$$ALDMC\ (\%) = (ALDW / ALFW) \times 100$$

Starting 15 September, fruits were collected periodically up to the end of the experiment (16-18 December 2021 and 2022). The average fruit number per branch (AFNB) and average fruit weight (g) were assessed.

2.4. Fruit Quality-Related Traits

Fruit samples were collected for analysis of fruit quality traits 10 days after the foliar spray of CPPU-1-FS treatment (on 25 September 2021 and 2022), 10 days after the second foliar spray of CPPU-2-FSs treatment (on 25 September and 15 October 2021 and 2022), and 10 days after the third foliar spray of CPPU-3-FSs treatment (on 25 September, 15 October, and 5 November 2021 and 2022). For each treatment, 20 fully colored fruits were randomly collected for the following evaluations. Average fruit total soluble solids (TSS, %) was measured in fruit juice using a digital refractometer (PR-100, Atago Co. Ltd., Tokyo, Japan) [19]. Fruit vitamin C content (mg $100g^{-1}$ FW) was evaluated as described in [20]. Fruit total soluble sugar content (%) was evaluated as described in [21].

2.5. Nutrient-Related Measurements

Nitric and perchloric acids were mixed at 3: 1 (v/v) for use in the digestion of dried fig fruit and leaf samples. The digested solution was used to estimate macro- and micro-nutrient contents (mg g^{-1} DW). The procedures described in [19] were utilized to evaluate N content using the micro-Kjeldahl apparatus (Ningbo Medical Instruments Co., Ningbo, China). The procedures listed in [22] were utilized to evaluate P content depending on the reduction rate of $H_3PMo_{12}O_{40}$ in H_2SO_4 by molybdenum to eliminate arsenic. The potassium (K^+) content was determined [17] using a flame photometer (Perkin-Elmer Model 52-A, Glenbrook, Stam-ford, CT, USA). The methods described in [23] were utilized to evaluate calcium (Ca), magnesium (Mg), and iron (Fe) contents (mg g^{-1} DW), against NIST (USA) standard reference samples using atomic absorption spectroscopy.

2.6. Photosynthesis-Related Measurements

The procedures described in [24] were followed to estimate the contents of total chlorophylls (TChls) and carotenoids (TCars) in mg g^{-1} fresh leaf tissue. TChls and TCars were extracted by homogenization of 100 mg sample in acetone solution (10 mL, 80%). The homogenates were centrifuged at 3,000 rpm for 20 min. Overnight, the samples were stored, then the supernatant absorbance was taken at 480, 645, and 663 nm. The fluorescence of Chl 'a' was evaluated using a handy PEA Chl-Fluorometer (Hansatech Instruments Ltd., Kings Lynn, UK). Fv/Fm (PSII maximum quantum yield) was evaluated through the equation [$Fv/Fm = (Fm - F0) / Fm$] [25]. The performance index (PI) of photosynthesis was computed [26].

2.7. Leaf Integrity-Related Measurements and Total Soluble Sugar Content

Relative water content (RWC) in leaf tissues was measured [27-29]. The RWC determination was based on the weights of leaf blade fresh, dry, and turgid masses. The membrane stability index (MSI) was calculated from the leaf tissue solution's electrical conductivity (EC) under warm (40 °C) (EC1) and boiling (100 °C) (EC2) conditions. The leaf tissue solution EC under normal (EC1), warm (45–55 °C) (EC2), and boiling (100 °C) (EC3) conditions were used for EL measurements. The following formulas were applied:

RWC (%) = [(fresh mass-dry mass) / (turgid mass-dry mass)] × 100
MSI (%) = [1-(EC1/EC2)] × 100
EL (%) = [((EC2-EC1))/EC3] × 100

Total soluble sugar content (mg g^{-1} DW) was measured colorimetrically (at 625 nm) using anthrone as a reagent freshly prepared in 72% sulfuric acid [21].

2.8. Experimental Design and Statistical Analysis

Both 2021 and 2022 experiments were arranged in a completely randomized block design with 9 replicates. Data were analyzed by one-way ANOVA with the SAS statistical software. Significant differences between means were assessed at a 5% level of probability ($p \leq 0.05$) using Tukey's HSD test. The GenStat 17th Ed. (VSN International Ltd., Hemel Hempstead, UK). The software was applied for statistical analysis.

3. Results

3.1. Photosynthesis-Related Parameters, Leaf Integrity, and Soluble Sugar Content

Table 2 indicates that foliar spray of CPPU only one time (CPPU-1-FS), foliar spray of CPPU two times (CPPU-2-FSs), or foliar spray of CPPU three times (CPPU-3-FSs) noticeably increased the contents of total chlorophyll and carotenoids in the 2021 and 2022 seasons. CPPU-3-FSs conferred the best findings, as it increased total chlorophyll content by 26.4 and 26.1%, and total carotenoids content by 51.4 and 59.5% in both seasons, respectively, compared to the controls.

Table 2. Response of leaf chlorophylls and carotenoids of fig trees to a foliar spray of CPPU in 2021 and 2022 main trials

Treatments	Season 2019	Season 2020	Season 2019	Season 2020
	Total chlorophyll content (mg g^{-1} FW)		Total carotenoids content (mg g^{-1} FW)	
Control	2.92±0.12d	3.03±0.49d	0.35±0.015d	0.37±0.016d
CPPU-1-FS	3.15±0.16c	3.28±0.73c	0.41±0.017c	0.43±0.018c
CPPU-2-FSs	3.24±0.18b	3.39±0.86b	0.45±0.019b	0.49±0.021b
CPPU-3-FSs	3.69±0.24a	3.82±0.98a	0.53±0.021a	0.59±0.028a

Control; distilled water applied as foliar a foliar spray three times, CPPU-1-FS; 40 µM forchlorfenuron applied as a foliar spray once only, CPPU-2-FSs; 40 µM forchlorfenuron applied as a foliar spray twice, and CPPU-3-FSs; 40 µM forchlorfenuron applied as a foliar spray three times. Foliar spraying was performed on October 1st for CPPU-1-FS treatment, October 1st and October 20th for CPPU-2-FSs treatment, and October 1st, October 20th, and November 10th for CPPU-3-FSs treatment. Samples for the analysis of photosynthesis-related parameters were collected from all treatments on November 20th.

Table 3 shows that CPPU-1-FS, CPPU-2-FSs, or CPPU-3-FSs noticeably increased contents of relative water and total soluble sugars in the 2021 and 2022 seasons. CPPU-3-FSs accorded the best findings, as it increased relative water content by 24.1 and 26.9%, and soluble sugar content by 43.3 and 36.9% in both seasons, respectively, compared to the controls.

Table 3. Response of leaf relative water content and total soluble sugar content of fig trees to a foliar spray of CPPU in 2021 and 2022 main trials

Treatments	Season 2019	Season 2020	Season 2019	Season 2020
	Relative water content (%)		Total soluble sugars content (mg g^{-1} DW)	
Control	71.5±2.22d	70.3±2.14d	20.1±0.42d	20.3±0.37d
CPPU-1-FS	77.2±2.69c	77.8±2.73c	24.2±0.47c	23.9±0.46c
CPPU-2-FSs	81.1±3.02b	81.9±2.96b	25.8±0.48b	25.7±0.47b
CPPU-3-FSs	88.7±3.47a	89.2±3.58a	28.8±0.56a	27.8±0.54a

Control; distilled water applied as foliar a foliar spray three times, CPPU-1-FS; 40 µM forchlorfenuron applied as a foliar spray once only, CPPU-2-FSs; 40 µM forchlorfenuron applied as a foliar spray twice, and CPPU-3-FSs; 40 µM forchlorfenuron applied as a foliar spray three times. Foliar spraying was performed on October 1st for CPPU-1-FS treatment, October 1st and October 20th for CPPU-2-FSs treatment, and October 1st, October 20th, and November 10th for CPPU-3-FSs treatment. Samples for the analysis of leaf integrity parameters and total soluble sugars content were collected from all treatments on November 20th.

3.2. Leaf Nutrient Contents

Table 4 indicates that CPPU-1-FS, CPPU-2-FSs, or CPPU-3-FSs noticeably increased all tested leaf nutrient contents in the 2021 and 2022 seasons.

CPPU-3-FSs collected the best findings, as it increased N content by 45.6 and 45.8%, P content by 65.2 and 60.0%, and K content by 70.5 and 56.7% in both seasons, respectively, compared to the controls.

Table 4. Response of leaf nutrient contents of fig trees to a foliar spray of CPPU in 2021 and 2022 main trials

Treatments	Season 2019	Season 2020	Season 2019	Season 2020
	Nitrogen content (N, mg g^{-1} DW)		Phosphorus content (P, mg g^{-1} DW)	
Control	1.71±0.09d	1.77±0.10d	0.23±0.005d	0.25±0.006d
CPPU-1-FS	1.92±0.11c	2.01±0.12c	0.28±0.006c	0.30±0.007c
CPPU-2-FSs	2.19±0.15b	2.18±0.14b	0.31±0.008b	0.33±0.009b
CPPU-3-FSs	2.49±0.19a	2.58±0.18a	0.38±0.010a	0.40±0.011a
	Potassium content (K, mg g^{-1} DW)			
Control	1.32±0.03d	1.41±0.03d		
CPPU-1-FS	1.54±0.04c	1.60±0.04c		
CPPU-2-FSs	2.16±0.06b	2.15±0.06b		
CPPU-3-FSs	2.25±0.06a	2.21±0.06a		

Control; distilled water applied as foliar a foliar spray three times, CPPU-1-FS; 40 µM forchlorfenuron applied as a foliar spray once only, CPPU-2-FSs; 40 µM forchlorfenuron applied as a foliar spray twice, and CPPU-3-FSs; 40 µM forchlorfenuron applied as a foliar spray three times. Foliar spraying was performed on October 1st for CPPU-1-FS treatment, October 1st and October 20th for CPPU-2-FSs treatment, and October 1st, October 20th, and November 10th for CPPU-3-FSs treatment. Samples for the analysis of nutrients were collected from all treatments on November 20th.

3.3. Growth, Late Fruit Yield, and Fruit Quality Traits

Table 5 points out that CPPU-1-FS, CPPU-2-FSs, or CPPU-3-FSs noticeably increased all tested parameters of fig tree growth and late yield components in the 2021 and 2022 seasons. CPPU-3-FSs granted the best findings, as it increased average leaf dry weight by 129.3 and 128.3%, and average leaf dry matter content by 30.2 and 31.2% in both seasons, respectively, compared to the control. In addition, CPPU-3-FSs increased average fruit number per branch by 129.7 and 125.6% and average fruit weight by 55.1 and 53.1% in both seasons, respectively, compared to the controls.

Table 5 also signalizes that CPPU-1-FS, CPPU-2-FSs, or CPPU-3-FSs noticeably improved fig fruit quality in the 2021 and 2022 seasons. CPPU-3-FSs conferred the best findings, as it increased fruit total soluble sugars by 40.5 and 45.6%, fruit total soluble solids by 35.2 and 34.7%, and fruit vitamin C content by 31.3 and 35.6% in both seasons, respectively, compared to the controls.

Table 5. Response of some growth and late yield parameters, as well as some fruit quality traits of fig trees to a foliar spray of CPPU in 2021 and 2022 main trials

Treatments	Season 2019	Season 2020	Season 2019	Season 2020
	Average leaf dry weight (g)		Average leaf dry matter content (%)	
Control	3.52±0.18d	3.61±0.19d	20.2±1.02d	20.5±1.07d
CPPU-1-FS	7.13±0.38c	7.12±0.40c	23.2±1.21c	22.5±1.26c
CPPU-2-FSs	7.21±0.42b	7.72±0.42b	24.8±1.28b	24.9±1.27b
CPPU-3-FSs	8.07±0.48a	8.24±0.49a	26.3±1.36a	26.9±1.34a
	Average fruit number branch^{-1}		Average fruit weight (g)	
Control	3.7±0.19d	3.9±0.21d	25.4±1.12d	26.2±1.17d
CPPU-1-FS	7.5±0.41c	8.1±0.42c	35.2±1.71c	36.0±1.76c
CPPU-2-FSs	7.9±0.45b	8.3±0.44b	36.6±1.88b	36.9±1.87b
CPPU-3-FSs	8.5±0.51a	8.8±0.52a	39.4±1.98a	40.1±1.99a
	Fruit total soluble sugars (%)		Fruit total soluble solids (%)	
Control	11.6±0.40d	11.4±0.48d	14.5±0.52d	15.0±0.61d
CPPU-1-FS	13.9±0.48c	13.7±0.55c	17.2±0.74c	17.8±0.74c
CPPU-2-FSs	14.8±0.54b	14.9±0.61b	18.0±0.78b	18.4±0.78b
CPPU-3-FSs	16.3±0.65a	16.6±0.79a	19.6±0.88a	20.2±0.92a
	Fruit vitamin C content (mg 100g^{-1} FW)			
Control	1.28±0.03d	1.32±0.04d		
CPPU-1-FS	1.41±0.04c	1.49±0.05c		
CPPU-2-FSs	1.55±0.04b	1.69±0.05b		
CPPU-3-FSs	1.68±0.05a	1.79±0.06a		

Control; distilled water applied as foliar a foliar spray three times, CPPU-1-FS; 40 µM forchlorfenuron applied as a foliar spray once only, CPPU-2-FSs; 40 µM forchlorfenuron applied as a foliar spray twice, and CPPU-3-FSs; 40 µM forchlorfenuron applied as a foliar spray three times. Foliar spraying was performed on October 1st for CPPU-1-FS treatment, October 1st and October 20th for CPPU-2-FSs treatment, and October 1st, October 20th, and November 10th for CPPU-3-FSs treatment. Samples for the analysis of growth parameters were collected from all treatments on November 20th. Fruit quality traits were assessed 10 days after the foliar spray of CPPU-1-FS treatment, 10 days after the second foliar spray of CPPU-2-FSs treatment, and 10 days after the third foliar spray of CPPU-3-FSs treatment.

4. Discussion

Warm climates and sufficient water are required for fig trees [4,5]. Therefore, in fig cultivation, the late fruit yield (September–December) in Egypt becomes less quantity and of lower quality compared to the main fruit yield (June–August) due to exposing the trees to lower temperatures. This negative result may be attributed to the reduced photosynthetic capacity under stress, which has a direct link with fruit yield and fruit quality [30]. However, the quantitative and qualitative traits of late fig fruit yield can be noticeably enhanced by using plant growth regulators (PGRs), including cytokinins (CKs) [6]. CKs play roles in delaying leaf senescence, stimulating plant cell expression and division, fruit setting and enlargement, and increasing crop yields [31,32]. These useful roles played by CKs could help improve the late fig fruit yield quantitatively and qualitatively along with prolonging the fruiting period. Through an experiment that lasted for two years (2021 and 2022), 40.0 μM CPPU contributed to the improvement in the late fig fruit yield quantitatively and qualitatively through enhancing photosynthesis, leaf integrity, and leaf contents of nutrients, including K and soluble sugars (Tables 2–5).

The leaf's main function is to provide different assimilates for the normal growth of crop plants through photosynthesis. As reported in a review [33], CK, at various levels, positively affects the functional and structural aspects of photosynthesis and increases the number of chloroplasts. This result is in favor of delaying leaf senescence by stopping the loss of chlorophyll and thus keeping leaf greenness (data not shown), which was reflected in the increased fruiting period of fig trees and also increased assimilates resulting from the improved photosynthesis in favor of the increased late fruit yield quantitatively and qualitatively (Tables 2–5). Confirming our findings (Table 2), Gashaw et al. [34] reported an improvement in chlorophyll (Chl) and carotenoid (Cart) stabilization after the application of 100 μM forchlorfenuron (CPPU) due to the incremented soluble sugars. In the photosynthetic system, photosynthetic pigments are pivotal complexes that harvest the light energy to convert it into chemical molecules (NADPH and ATP; reducing powers) to complete the dark reaction. Consequently, Chl and Cart stabilities in fig trees under stress (low temperature late in the production season; September–December) by the application of 40.0 μM CPPU distinctly resulted in this report. In addition, Gujjar et al. [35] reported an abundance of chlorophyll synthase protein in CPPU-treated plants and maintenance of a sufficient level of this enzyme under stress in favor of improved Chl content and thus enhanced photosynthesis efficiency. As also reported in [36], CPPU inhibits the enzyme cytokinin oxidase from degrading Chl, maintaining adequate Chl content for the benefit of photosynthesis.

The presence of sufficient soluble sugars (Table 3) helps plant cells retain as much water as is required for these vital processes [37-40]. These requirements were achieved by CPPU treatment for fig trees, optimizing leaf relative water content (RWC) through increasing soluble sugar content (Table 3). This improvement may also be due to the improved ion balance (Table 4) by CPPU treatment to protect cellular membranes and optimize RWC (Table 3). Our results signalize the presence of osmotic balance in fig leaves, represented by a marked increase in soluble sugar content, to enable the root system, as a barrier, to uptake enough water for maintaining optimal RWC and metabolic processes. These findings are consistent with those in [41-45] using different CKs.

Our results showed an augmentation in all examined leaf and fruit nutrients, including nitrogen (N), phosphorus (P), and potassium (K) (Table 4). This positive finding may be due to tree metabolic processes and increased soluble sugars (Table 3), which enable plants to effectively uptake water and different nutrients dissolved in water. Among the roles played by CK-like substances are stimulating cell expansion and division [31], which may increase the absorbing surfaces of the root system to increase water and nutrient uptake efficiently. The increased content of K may enhance the other nutrient (N and P) contents through water movement induced by the regulatory role of K in trans-membrane potential and osmotic pressure in xylem tubules [46].

The functions of hormones, including cytokinins (e.g., CPPU) in stimulating cell expansion and division are among the hormonal responsibilities that led to increased fig tree growth traits (Table 5), which, along with increasing assimilates resulting from enhanced photosynthesis (Table 2), contributed to increased fruit yield components and fruit quality traits. Zeng et al. [47] revealed that CPPU treatment augmented fruit set and fruit yield in *Macadamia integrifolia* because CPPU was effective in minimizing fruit drop. Fruit is a strong sink for metabolites, and fruit set is strongly related to soluble sugar availability and CPPU regulates soluble sugar distribution [48,49]. CPPU enhanced the export of soluble sugars from leaves to fruits and promoted carbohydrate utilization in bearing branches. Therefore, CPPU augmented the sugar availability in the bearing branches to improve fruit retention and quality [47]. Our findings signalized an improvement in tested fig fruit quality traits (fruit total soluble solids, fruit soluble sugars, and vitamin C) by CPPU treatment, all are consistent with those in [50,51]. Some reports [50,52,53] reported that CK treatment increases the sink sturdiness and the impact varies depending on the stage of cell development. Also, CPPU treatment can stimulate strong fruit sink strength that can compensate for the high fruit growth and not reduce the fruit's total soluble solids.

5. Conclusions

All results obtained indicated that the application of 40 μM forchlorfenuron (CPPU) in three foliar sprays could improve the late fruit yield and fruit quality traits of fig trees due to improved photosynthesis, and leaf contents of nutrients. In a physiological approach, the increased leaf relative water content contents of leaf soluble sugars and nutrients in fig trees may improve the late fruit yield along with enhancing fruit quality traits. This study open the way for further scientific investigation using CPPU and to explore more precise explanations for the increase in late fruit yield and fruit quality traits. The results of this study confirmed the hypothesis that the application of the plant growth regulator CPPU at 40 μM in three foliar sprays could stimulate the defensive response of the fruit to overcome the adverse conditions causing low late fruit yield and fruit quality traits.

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Author Contributions

Conceptualization, M.M.M.A., H.R.B., A.G.A.A., H.E.E.B., M.E.M.M., and M.M.R.; investigation, M.M.M.A., H.R.B., A.G.A.A., H.E.E.B., and M.E.M.M., data curation, M.M.M.A., H.R.B., A.G.A.A., H.E.E.B., M.E.M.M., and M.M.R.; formal analysis, M.M.M.A., I.A.A.M., and M.M.R.; methodology, M.M.M.A., H.R.B., A.G.A.A., H.E.E.B.,

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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