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Evaluation of the Bio-efficacy of a Flavonoid-based Foliar Spray, on Growth and Yield of Tomato (Solanum lycopersicum L.)

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Abstract

In the Rabi season of 2023–24, a field experiment was undertaken to assess the bio-efficacy of CropBioLife, a flavonoid-based foliar spray, on the tomato crop, located at the Tomato Improvement Scheme, MPKV, Rahuri. The significantly affected growth, yield and fruit quality parameters of tomato by CropBioLife in the field experiment utilized a randomized block design with five treatments and four replications on the variety 'Dhanashree'. The observed treatment included the CropBioLife foliar application which resulted in improved growth, yield and fruit quality parameters. The 2 ml/L dosage (Treatment T_4) observed the tallest plants (107.12 cm), earliest flowering (29.14 days) from flowering to fruit formation, highest fruit number (25.72 fruits/plant), maximum average fruit weight (78.50 g) and yield (57.82 t/ha). CropBioLife produced the maximum TSS value (4.60 °B), this effect was dependent on the dose used until 2 ml/L, and the higher dosage did not improve the yield more than 2 ml/L. Therefore, CropBioLife has shown to be potential evident to be effectively an option to improve behaviour of tomato productivity potential and quality.

Key words: Tomato, CropBioLife, flavonoid, yield, productivity.

1. Introduction

Tomato (Solanum lycopersicum L.) is among the most significant vegetable crops cultivated globally. The vital significance of this crop is not limited to its nutritional and culinary qualities (vitamins A, C and lycopene), but also as a means of livelihood for farmers and agro-economic significance. Since it is the second-largest nation on earth, India crops tomato over 870,000 hectares worth approximately 21 million metric tonnes every year (FAOSTAT, 2022). In India, tomato crops are widely cultivated in all areas, but the productivity is frequently hampered by biotic and abiotic constraints.

The most significant constraints to tomato production can be drought, temperature fluctuations, poor soil fertility, pest and disease pressures and dependence on chemical inputs that diminish soil health over time. The impact of dependence on imbalanced soil fertilization along with pesticide over-use has been related to reduced quality of the crops and lower environmental sustainability. Once again, responding to biotic and abiotic constraints in tomato production and in modern horticulture, eco-friendly and biologically active inputs, such as flavonoid-based foliar sprays, can be used sustainably and durably.

Flavonoid-based foliar sprays are substances or microbes that, when used on plants or soils, induce natural processes for improving nutrient and water uptake, tolerance to environmental stresses and general plant health, regardless of their nutrient value (du Jardin, 2015). They mark an important transition from input-driven agriculture to input-savvy systems. Flavonoid-based foliar sprays exist in diverse forms which include seaweed extracts, protein hydrolysates, humic acids, bacteria and beneficial fungi and increasingly, plant derived secondary metabolites such as flavonoids.

Flavonoids are a large and heterogeneous group of polyphenolic compounds produced by plants largely via the phenylpropanoid pathway which can impart colour to plant tissue, provide protection from UV radiation, can potentially enhance interactions with symbiotic microorganisms, and they may play a role in a plant's defence responses. Recently flavonoids have been of interest because of their hormone-like effects that influence auxin transport, root development, stomatal conductance and the mitigation of oxidative stress (Falcone Ferreyra et al., 2012). Their applications in enhancing abiotic stress tolerance, photosynthetic performance and modulation of plant–microbe association have been extensively reported under controlled conditions (Buer et al., 2008; Agati et al., 2012).

CropBioLife is a new flavonoid-based foliar spray formulation from Aussan Laboratories, Australia based on a proprietary consortium of bioactive flavonoids. Early studies and subjective observations from the field indicated that CropBioLife facilitates improved crop vigour, flowering and fruit setting by modulating physiological pathways related to stress response, carbon assimilation, and root exudation. However, scientific evaluations in the field of the efficacy of CropBioLife in the commercially important crop of tomato are few and warrant scientific inquiry.

To this end, this study attempted to assess the bio-efficacy of CropBioLife in field conditions on tomato with a specific focus on vegetative growth, reproductive processes, yield performance and quality of fruit. The results of the study are hoped to contribute towards the evidence base for flavonoid-based foliar sprays in sustainable horticulture.

2. Materials and Methods

2.1 Experimental Site and Design

The study was done during Rabi 2023–24 at the Tomato Improvement Scheme, Department of Horticulture, MPKV, Rahuri (Ahmednagar, Maharashtra). The design of the experiment was randomized block design (RBD) with five treatments and four replications.

2.2 Crop and Treatments

Dhanashree tomato variety was used, with spacing of 90 × 30 cm and plot size of 3.6 x 3.3 m^2. The following treatments were evaluated:

Treatment	Dosage	Application
T_1	Untreated Control	Water
T_2	CropBioLife (CBL)	0.5 ml/L
T_3	CropBioLife (CBL)	1 ml/L
T_4	CropBioLife (CBL)	2 ml/L
T_5	CropBioLife (CBL)	4 ml/L

Three foliar applications were performed at 5, 30 and 60 days after transplanting (DAT), using a Knapsack sprayer.

2.3 Cultural Practices

All plots received a uniform basal application of 300:150:150 kg NPK/ha and 20 tons/ha of farmyard manure. Standard agronomic practices were followed throughout the cropping period.

2.4 Data Collection

Growth and yield parameters recorded included:

- Plant height (cm)
- Days to 50% flowering
- Number of branches per plant
- Average fruit weight (g)
- Number of fruits per plant
- Yield per plant (kg), per plot (kg) and per hectare (t/ha)
- Total Soluble Solids (TSS, °Brix)

2.5 Statistical Analysis

Data were analysed using standard ANOVA procedures for randomized block designs, with treatment means compared using the Critical Difference (CD) at 5% significance.

3. Results and Discussion

This experiment assessed the influence of different concentrations of CropBioLife (CBL) (a flavonoid-based foliar spray) on the growth, yield and fruit quality of tomato (variety- Dhanashree). The five treatments included a control (T_1) and foliar applications of CBL at concentrations of 0.5 ml/L (T_2), 1 ml/L (T_3), 2 ml/L (T_4) and 4 ml/L (T_5) applied three times throughout the crop cycle. CropBioLife was correlated with a statistically significant increase in most of the parameters assessed, especially at the 2 ml/L concentration.

3.1 Plant Height

There was a recognizable increase in plant height in response to the CBL application. Treatment T_4 had the highest plant height (107.12 cm) followed by T_3 (99.74 cm) and T_5 (99.11 cm) with the lowest being treatment T_1 (97.18 cm), which still had a significant response over the height of the control plant. This indicates that CropBioLife could be beneficial in enhancing vegetative growth of crops likely due to enhancing the uptake of nutrients and physiologically active regulatory processes of photosynthesis via the influence of flavonoids. The difference was statistically significant and was promoted by T_4 as it was higher than all other treatments.

These results align with earlier research which has shown that bio-stimulants that are polyphenolic can promote shoot elongation and biomass by possibly modulating endogenous hormone levels and enhancing the root exudation of organic molecules (Treutter, 2005; Buer et al., 2008).

3.2 Days to 50% Flowering

CBL treatments resulted in faster flowering than the control. The fastest flowering was observed in T_4 (29.14 days) and T_3 (29.27 days) with the two treatments showing a delay in flowering (T_1, 31.26 days, T_2, 31.47 days). Although differences were statistically non-significant, it does appear that CBL and more specifically, at 1 and 2 ml/L may help accelerate transition to a reproductive phase. This acceleration could be assisted by improved hormonal signalling and ultimately plant vigour. Flavonoids have been shown to regulate hormonal balance and modulate photomorphogenic signalling (Zhao, 2010; Treutter, 2005), which may contribute to flowering time.

3.3 Number of Branches per Plant

Branch number per plant was not statistically different between treatments but there was a trend for more branches for T_4 (7.04) followed by T_1 (6.74) then T_3 (6.65). The trend suggests that CBL application may be increasing lateral growth and shoot development. Flavonoids are known to alter auxin gradients and modulate polar auxin transport which are two factors that regulate shoot branching patterns (Buer et al., 2006; Negi et al., 2008). Both studies suggest that although statistically non-significant, the improved vegetative architecture evident in T_4, may be related to the previously-mentioned mechanism.

3.4 Number of Fruits per Plant

There was a significant increase the number of fruits per plant due to CBL application. T_4 (25.72) was the highest number of fruits, significantly greater than the control T_1 (22.42), other treatment groups, T_3 (24.31) and T_5 (24.08) were also significantly more than the control. The increased fruit set and retention may have been due to improved plant nutrition and once again reduced oxidative stress and improved hormonal signalling during reproductive stages due to CBL which is evident of the positive impact of CBL. These findings are consistent with the known roles of flavonoid-based foliar sprays on reproductive performance (Rouphael & Colla, 2020; Calvo et al., 2014).

3.5 Average Fruit Weight

CBL treatments improved average fruit weight significantly. The greatest mean fruit weights were T_4 (78.50 g) and T_3 (78.40 g), while control (68.64 g) was the least, and T_5 (74.36 g) and T_2 (73.33 g) also significantly improved over control. It is possible that CBL was improving fruit weight through cell expansion or improving sink strength. Flavonoids, known to regulate both auxin transport and sugar distribution, can be key components to fruit development and enlargement (Buer et al., 2006; Davies, 2005). It is mentioned that auxin transport may facilitate better fruit size through sink strength (Buer et al., 2008).

3.6 Yield Parameters

The overall yield was highest in T_4 (2 ml/L), and was supported by further measures of flowering, fruit count and fruit size. While T_5 (4 ml/L) also performed well, it did not exceed T_4 and showed very slight decreases in some traits. It appears there may be a threshold range to adhere to, where once a concentration or other factor exceeds it, there is minimal benefit and decreasing yield. This is consistent with the concept of 'hormesis', where flavonoid-based foliar sprays can often demonstrate ideal optimum levels and will demonstrate a higher yield and or affect with lower concentrations, rather than higher where excessive amounts become toxic (Calvo et al., 2014).

3.7 Total Soluble Solids (TSS)

As TSS is used to measure both sweetness and fruit quality, results were significantly greater with all CBL treatments. T_4 (4.60 °B) showed the greatest TSS average, followed by T_5 (4.40 °B) and T_2 (4.26 °B). The control produced the lowest TSS in the experiment at 3.81 °B. The greater TSS figures from treated plants illustrates a likely improvement in the plant's ability to synthesize and partition carbohydrates and probably improved photosynthesis and senescence delay. Under moderate and severe stress conditions, flavonoids improve and maximize light utilization and have been shown to improve sugar accumulation (Agati et al., 2012; Tattini et al., 2000).

Table 1: Bio-efficacy study in tomato for CropBioLife (Rabi 2023-24)

Treatment	**Plant height (cm)**	**Days to 50 % flowering**	**No of branches per plant**	**No of Fruit per plant**	**Avg. wt. of fruit (g)**	**Yield per plant (kg)**	**Yield per plot (kg)**	**Yield (t/ha)**	**TSS (^{0}B)**
T_1 : Control (Water)	97.18	31.26	6.74	22.42	68.64	1.64	59.18	49.82	3.81
T_2 : 0.5 ml (CBL)	96.36	31.47	6.24	23.46	73.33	**1.77**	63.54	53.49	4.26
T_3 : 1 ml (CBL)	99.74	29.27	6.65	24.31	**78.40**	**1.84**	**66.20**	55.73	4.00
T_4 : 2 ml (CBL)	**107.12**	29.14	7.04	**25.72**	**78.50**	**1.91**	**68.70**	**57.82**	**4.60**
T_5 : 4 ml (CBL)	99.11	30.34	6.61	24.08	**74.36**	**1.79**	64.46	54.26	4.40
S.E.+	2.65	0.97	0.91	0.71	2.06	0.06	2.48	2.08	0.25
C.D. at 5 %	6.18	NS	NS	2.09	6.01	0.09	6.12	6.12	0.75

3.8 Weather Conditions During the Experiment

3.8.1 Temperature Trends

In figure 1, the temperature trends during the experiment are illustrated. The meteorological observations recorded in the month of October 2023, the first vegetative growth stage of the tomato crop, showed a relatively stable maximum temperature between 30.0°C and 35.0°C. The maximum temperature during this month was recorded as 35°C on October 15, while the minimum temperature was recorded as 16.7°C on October 31, which is notably the lowest minimum temperature of the month (Mohsin et al. 2021). While the temperature was reported as gradually declining for each subsequent day of October, a gradual process of accumulation through the rest of the month is typical to the transition into Rabi season of northern Cape Coast where flowering induction under tomato cultivation is positive).

A general thermal regime for vegetative and early reproductive development under tomato cultivation can facilitate growth when temperatures remain within their bounds; however, consistent drastic increases or further deviations typically will have negative impacts on viability of pollen and fruit set (for example elevated warm night temps) (Adams et al., 2001). Fortunately, no such extremes in thermal regime(s) occurred during this period.

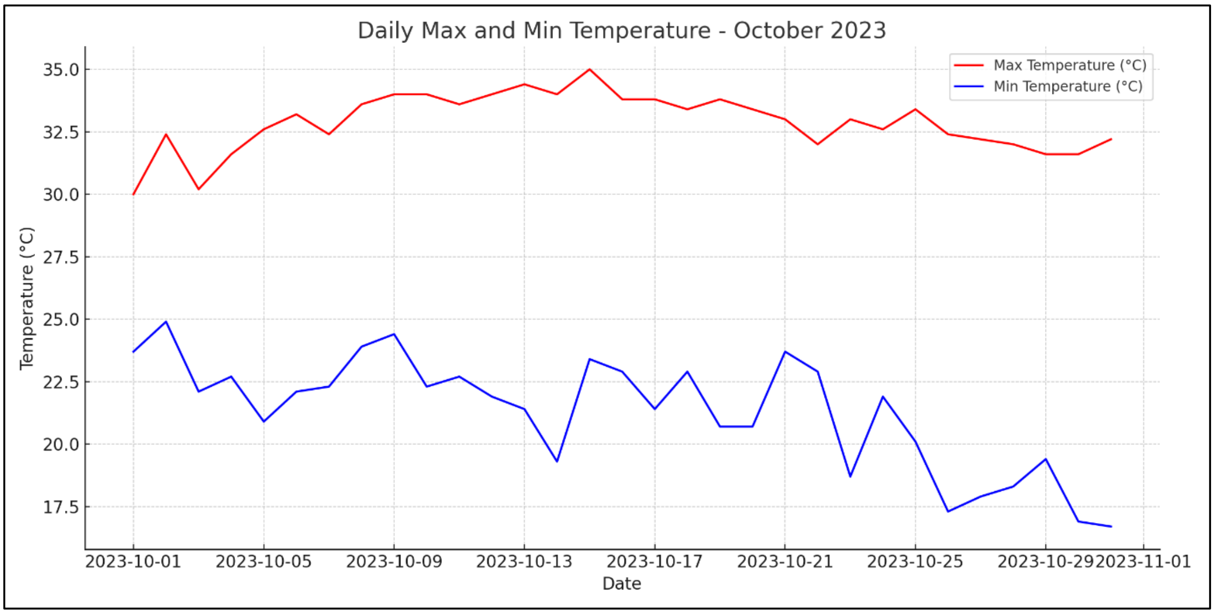

Fig. 1 Temperature trends during the experiment

3.8.2 Relative Humidity Trends

Relative Humidity (RH) readings underwent the typical diurnal fluctuations observed under summer conditions, where RH I (morning) heights in RH readings were consistently greater than RH II (afternoon). Morning RH (RH I) measured 60% to 93% during the sampling period, seeing the most considerable readings during the first week of October. Afternoon RH (RH II) ranged from 19% to 52%, indicating moderately dry afternoons, which would allow for beneficial field operations and help suppress disease incidence and intensity.

The variations in the RH readings suggest that there would be intermittent dew formation early in the morning, with a dry microclimate developing by noon, which would substantially reduce the probability of foliar diseases being a concern. This dry microclimate likely facilitated adequate uptake when applying the flavonoid-based foliar spray CropBioLife, during the early spray events (5 DAT and 30 DAT) and producing physiological responses.

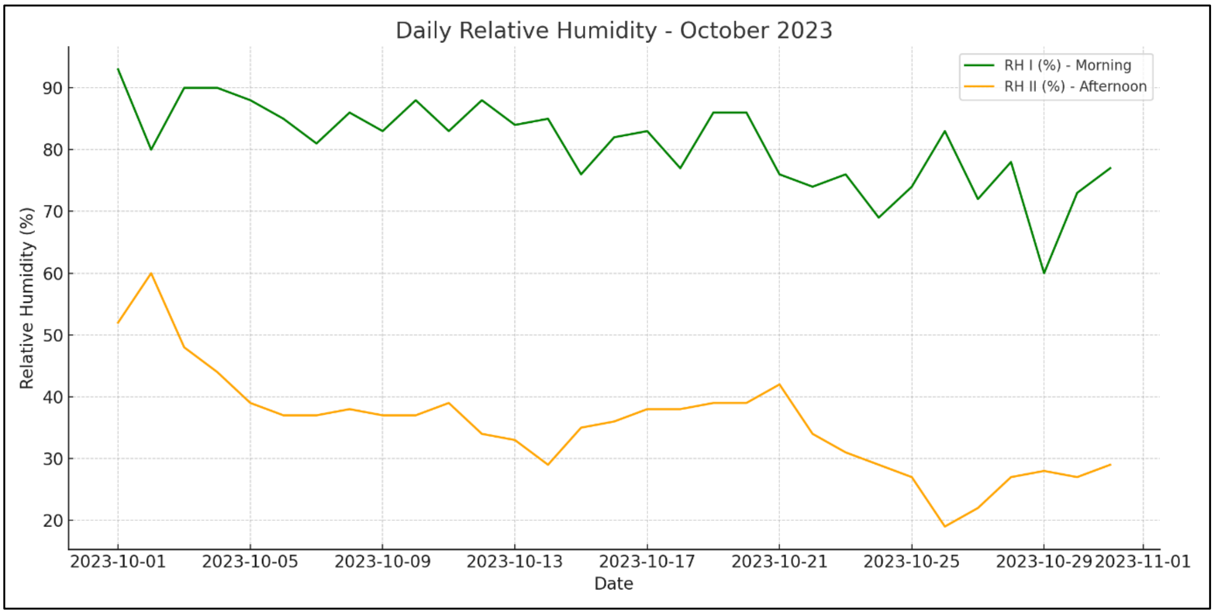

Fig. 2 Humidity trends during the experiment

3.8.3 Significance for CropBioLife Application

The relatively stable temperature and humidity regime throughout October allowed for optimal crop establishment and early-growth periods, which are critical for the successful application of flavonoid-based foliar sprays. Additionally, high humidity in the morning hours likely assisted with leaf surface wetness, cuticle permeability, and overall absorption efficiency of CropBioLife. There was very little to no extreme rainfall events (other than what occurred on October 3) which also assisted with avoiding nutrient leaching and maintaining flavonoid-based foliar spray available on the foliage, for sufficient time post-application.

4. Conclusion

The current research showed that foliar application of CropBioLife, a foliar spray made from flavonoids, significantly enhanced growth, yield and fruit quality of tomato (Solanum lycopersicum L., var. Dhanashree) under field conditions. The optimal concentration was 2 mL/L with respect to growth, yield and fruit quality, because plants at 2 mL/L were taller, flowering was earliest, greatest fruit number was found, greatest average fruit weight, and highest yield of 57.82 t/ha and highest TSS (4.60 °Brix) over the control etc. Higher concentrations did not provide as great greater benefits compared to the 2mL/L, thereby suggesting that a threshold concentration is important in dosing. There are likely many physiological improvements following the CropBioLife application, due to the potential conditioning effects of flavonoids on nutrient uptake, and hormonal balance and presumably altered processes.

The findings indicate that CropBioLife at 2 mL/L can serve as an environmentally-friendly, sustainable input / substitute for enhanced tomato productivity and quality with a potential to decrease dependency on synthetic agrochemicals. Further trials across multiple locations and seasons and agro-climatic conditions are recommended to confirm and further understand the mechanistic pathways of these findings.

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