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Developmental and Quality Traits of Tomato (*Lycopersicon esculentum* mill.) Cultivars as Affected by Albit[br] Bio-stimulant

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ABSTRACT

Background: Changes in the climate of the world coupled with the indiscriminate application of chemical fertilizers are causing great challenges in agricultural production systems. However, such problems could be tackled by using bio-stimulants leading to the advancement of sustainable production. Thus, the current study was conducted with the purpose of improving quality traits and fruiting potential of tomato plants using albit[br] bio-stimulant.

Methods: The study involved seven doses of the albit[br] bio-stimulant (0.1 L ha^{-1}, 0.5 L ha^{-1}, 1 L ha^{-1}, 2.5 L ha^{-1}, 5 L ha^{-1}, 10 L ha^{-1} and 50 L ha^{-1}) applied on four tomato cultivars (Malets, Revansh, Talisman and Fonaric) to be compared against the control (lone water). The field was designed in a randomized block design and each treatment was replicated three times. Two plants were randomly selected from each plot for data collection.

Result: Results indicated that Fonaric cultivar produced the highest significant values of carotenoid pigments, chlorophyll b and total chlorophyll. In addition to this, the highest significant values of number of fruiting trusses per plant and number of fruits per truss were obtained from Malets cultivar. Albit[br] bio-stimulant application resulted into significant differences on most of the parameters. Albit[br] applied at 5 L ha^{-1} produced the highest significant values of total chlorophyll (1.966 mg g^{-1}), chlorophyll b (0.759 mg g^{-1}), number of fruits per truss (3.812) beta carotene (2.509 mg 100 g^{-1}) whereas the highest levels of chlorophyll a (1.263 mg g^{-1}) and lycopene (15.45 mg 100 g^{-1}) were obtained from 2.5 L ha^{-1} and 10 L ha^{-1} respectively.

Key words: Bio-stimulant, Climate, Completely randomized block design, Cultivar, Tomato.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important fruit vegetable for human consumption. It is grown in many countries due to its adaptability to a wide range of soil and weather conditions (Cammarano *et al.*, 2022). It is a rich source of phytochemicals like carotenoids, (polyphenols and vitamins as well as minerals, offering a wide range of health benefits to consumers (Bakir *et al.*, 2023; Buturi *et al.*, 2022). Since, the food manufacturing process of plants depend on the chlorophyll composition of the plants predominantly the leaves, the amount of chlorophyll that a plant has determines the production potential. The transition from ovary to fruit (fruit set), is the most critical step in fruit development because the ovary is programmed to abort if ovules are not fertilized (Hu *et al.*, 2023) which is possibly influenced by prevailing weather conditions. Carotenoids are tetraterpene pigments which are essential part of the human diet having a major impact on human health (Bufka *et al.*, 2024). High-temperature stress can cause leaf yellowing, stunted growth and tissue wilting in tomatoes, significantly reducing both yield and quality (Aldubai *et al.*, 2022). High temperatures seriously affect chlorophyll metabolism in tomato seedlings, thereby inhibiting photosynthesis (Ding *et al.*, 2022). Under deficit irrigation, Though plants are expected to produce higher amounts of abscisic acid (ABA) and β-carotene-derived major phytohormone under water deficit as a response to abiotic stress (Mi *et al.*, 2022), β-carotene can be broken down through non-enzymatic cleavage by reactive oxygen species (ROS) (Ramel *et al.*, 2013).

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Climate change is putting more pressure on the resources that feed people and increasing the rate of biotic and abiotic stresses on crops, which in turn is raising questions about whether the planet can feed its people or not (Mariani and Ferrante, 2017). Tomato being subject to a variety of biotic and abiotic stresses during its life cycle (Bai *et al.*, 2018), several techniques should be used to improve abiotic stress tolerance in cultivated tomato, which include breeding programs, cultural practices and biotechnological approaches (Alsadon *et al.*, 2020). In addition to the negative consequences posed by climate change, the indiscriminate application of inorganic

fertilizers also led to the accumulation of heavy metals resulting in polluted soils ultimately leaving human health in jeopardy (Jote, 2023). At present, organic nutrient sources are prioritized over synthetic chemicals despite the concerns arising regarding the availability of a sufficient quantity of organic materials for agricultural needs (Krithika *et al.*, 2025). The use of bio-stimulants has been considered an effective way to achieve sustainable agricultural production and to maintain soil health (Shabani *et al.*, 2023). Active ingredient of albitbr bio-stimulant; poly-hydroxybutyric acid (PHB) obtained from soil bacteria (*Bacillus megaterium De Bary.* and *Pseudomonas aureofaciens Kluyver.*) (Bilinska *et al.*, 2021), improves plant growth and reduces the dependence of farmers on chemical fertilizers and pesticides, promoting sustainability of agro-systems (Kalozoumis, 2023). Thus, the current study was conducted to assess the impact of Albitbr bio-stimulant application on fruiting and quality characteristics of tomato cultivars.

MATERIALS AND METHODS

The study was conducted in the federal state budgetary scientific institution federal scientific vegetable center, VNIISSOK, moscow region, Russia during in 2024 (May-August) on four tomato cultivars: Revansh, Malets, Talisman and Fonaric. The bio-stimulant "Albit^{br}" was applied in different doses (0.1 L ha^{-1}, 0.5 L ha^{-1}, 1 L ha^{-1}, 2.5 L ha^{-1}, 5 L ha^{-1}, 10 L ha^{-1} and 50 L ha^{-1}) on the soil one day before transplanting to be compared against the control (lone water). The field was laid out in a randomized block design (RBD) with three replications and each plot had an area of 2.1 m^2. Seedlings were transplanted at a spacing of 70 cm × 37.5 cm. Observations were recorded from two randomly selected plants on chlorophyll content, fruit set (%), number of fruiting trusses per plant, number of fruits per truss, fruit water content (%), carotenoid contents. Water content of fruits was computed gravimetrically by drying 1 g tomato in an oven at 105-110°C for 2 hours (Giosanu *et al.*, 2016) and expressed as g 100 g^{-1} Fresh weight.

To measure chlorophyll content, 0.25 g of leaf sample was ground in 2 mL of 80% acetone, then samples were filtered through filter papers and the final volume was completed to 25 mL (Ali *et al.*, 2021). Lastly the chlorophyll content was determined according to the method used by (López-Vargas *et al.*, 2020). The absorbances at 645 nm and 663 nm were determined and subsequently used the following equations to determine the content of chlorophyll. Chlorophyll a = 0.999 × Abs 663 - 0.0989 × Abs 645, Chlorophyll b = -0.328 × Abs 663 + 1.77 × Abs 645 and total chlorophyll= Chlorophyll a + Chlorophyll b. All data are expressed as mg g^{-1} dry weight.

Carotenoids were evaluated using a method described by Petropoulos *et al.* (2020) and Fernandes *et al.* (2022). Fruit samples of 500 mg were vigorously shaken with 10 mL of acetone and hexane mixture (4: 6, on volume basis) for 1 minute and filtered through Whatman Number 4 filter paper. The absorbance was measured at 453 nm, 505 nm, 645 nm and 663 nm and the content of carotenoids (β-carotene and lycopene) was obtained by using the following equations and expressed in mg 100 g^{-1} of dry weight:

$$\beta\text{-carotene (mg 100 g}^{-1}) = 0.216 \times A663 - 1.220 \times A645 - 0.304 \times A505 + 0.452 \times A453$$

$$\text{Lycopene (mg 100 g}^{-1}) = -0.0458 \times A663 + 0.204 \times A645 - 0.304 \times A505 + 0.452 \times A453$$

The data collected was analyzed using gene-stat software (version 2011) through analysis of variance and the mean comparison was made at 5% level of significance using the critical difference (CD) or least significant difference (LSD) values. The LSD values were used for comparison of the differences of values between the mean for those parameters whose treatments showed F probability less than 0.05. Mean differences which are greater than the LSD value refers to significant difference.

RESULTS AND DISCUSSION

Chlorophyll a

Significant variation was noticed on chlorophyll "a" of tomato leaves upon using different cultivars (Table 1). Out of the four cultivars, Talisman cultivar produced the highest value (1.203 mg g^{-1}) significantly surpassing both Revansh and Malets cultivars by 15.1% and 10.9% respectively. However, Talisman Cultivar did not show significant variation in the chlorophyll "a" composition compared to fonaric cultivar recording an intermediate value 1.198 mg g^{-1}. Like the cultivar effect, chlorophyll A content was seen to be significantly influenced by the application of albitbr bio-stimulant (Table 1). The bio-stimulant applied at 2.5 L ha^{-1} led to the production of the highest value (1.263 mg g^{-1}) followed by 5 L ha^{-1} (1.207 mg g^{-1}) and the lowest value was obtained from the untreated plots (0.943 mg g^{-1}). A maximum difference of 0.32 mg g^{-1} of chlorophyll A was recorded between plants treated with 2.5 L ha^{-1} and the non-treated plants. Plants treated with a dose of the bio-stimulant at the dose of 2.5 L ha^{-1} were found to exhibit a significantly superior value of chlorophyll "a" compared to control plants and also plants treated with 0.1 L ha^{-1}, 0.5 L ha^{-1} and 1 L ha^{-1}. In agreement with the current results, Turan *et al.* (2023) reported a significant increase in chlorophyll A by using commercial bio-stimulant product (Microsense® Root) applied at a rate of 6 L ha^{-1} by alleviating the negative impacts of drought stress as is with albit bio-stimulant.

Chlorophyll b

Planting different cultivars resulted in significant variations in the chlorophyll "b" composition of leaves (Table 1). Fonaric cultivar was observed to express the highest significant value (0.692 mg g^{-1}) as compared to all the other three cultivars and it was followed by Talisman (0.658 mg g^{-1}). A 23.8% increase in chlorophyll "b" of tomato leaves was shown between Fonaric and Malets cultivars which produced the highest and lowest values respectively.

In the same way, application of albitbr bio-stimulant also significantly influenced chlorophyll "b" content of tomato leaves (Table 1). The highest value (0.759 mg g^{-1}) was obtained from 5 L ha^{-1} dose of the bio-stimulant followed by 10 L ha^{-1} (0.714 mg g^{-1}) and the lowest value (0.445 mg g^{-1}) was recorded by applying 0.5 L ha^{-1} of the bio-stimulant. The bio-stimulant dose 5 L ha^{-1}, being the one that resulted into the highest value tend to have a significant superiority as compared to all the doses of the bio-stimulant except 10 L ha^{-1} dose. It has also been observed that plants treated with all the five higher doses starting from 1 L ha^{-1} to 50 L ha^{-1} tend to exhibit significantly better results of the chlorophyll "b" content as compared to the control. A maximum difference of 0.26 mg g^{-1} of chlorophyll "b" was registered between the non-treated plants and other plants treated with 5 L ha^{-1} of albitbr. In line with the results of this experiment, Turan *et al.* (2023) reported that commercial bio-stimulant product (Microsense® Root) applied at a rate of 6 L ha^{-1} significantly increased chlorophyll B compared to control.

Total chlorophyll content

Significant differences were observed on the total chlorophyll composition of tomato leaves among the four cultivars used in this study (Table 1). From the four cultivars, Fonaric showed the highest value (1.89 mg g^{-1}) followed by Talisman (1.861 mg g^{-1}) whereas the lowest value was recorded by Revansh cultivar (1.604 mg g^{-1}). Total chlorophyll composition differences recorded by Fonaric cultivar upon comparing it with both Malets and Revansh cultivars was 14.6% and 17.8% respectively. Despite the fact that there was no significant variation in between the two highly performing cultivars (Fonaric and Talisman), they both showed significantly increased values of the total chlorophyll content upon comparison with both Malets and Revansh cultivars. The significant difference observed in the current study is possibly due to the genetic differences for their pest resistance potential which was supported by Ikram *et al.* (2022) reporting significant differences in chlorophyll content. Having observed a significant influence of the Bio-stimulant application on the total chlorophyll composition of tomato leaves, all the albitbr doses greater than 1 L ha^{-1} exhibited significantly higher values when compared to the control treatment (Table 1). The highest value was recorded from 5 L ha^{-1} (1.966 mg g^{-1}) followed by 2.5 L ha^{-1} (1.911 mg g^{-1}) and the maximum discrepancy of the total chlorophyll content (36.2%) was obtained between plants treated with 5 L ha^{-1} and control. In line with these results, Kalozoumis (2023) reported: Albit (PHB) treatment is the most successful in promoting chlorophyll synthesis as compared to the control especially during the initial stages of cultivation.

Fruit set

As per the findings of the experiment, there existed a significant variation in the fruit set values among the four cultivars used in the study. Malets cultivar showed the highest significant value (75.73%) as compared to the all the other three cultivars and it was followed by Talisman cultivar (60.39%). Malets cultivar tend to possess 33.4%

Table 1: Impact of albitbr bio-stimulant on leaf chlorophyll content, fruit development and fruit quality traits of tomato cultivars.

Treatments	Parameters							
Cultivars	Ch A (mg/g)	Ch B (mg/g)	Tot. Ch (mg/g)	Lyco (mg/100 g)	B.Car (mg/100 g)	FWC (%)	FS (%)	NT/P
Fonaric	1.198	0.692	1.89	14.54	2.403	93.58	56.77	7.6
Malets	1.085	0.565	1.65	14.29	2.256	93.37	5.73	16.12
Revansh	1.045	0.559	1.604	12.86	1.996	93.48	59.12	11.73
Talisman	1.203	0.658	1.861	14.26	2.094	93.84	60.39	10.19
(Sem±)	0.0306	0.0358	0.0632	0.467	0.1042	0.1701	1.177	0.312
CD (<0.05)	0.0864	0.1012	0.1788	1.321	0.2946	NS	3.327	0.882
Albit^{br} doses (L/ha)								
Control	0.943	0.49	1.443	13.31	2.088	93.92	64.75	11.08
0.1	1.077	0.549	1.626	13.93	2.217	93.48	63.57	11.54
0.5	1.063	0.445	1.508	12.50	1.823	93.56	60.07	11.21
1	1.137	0.651	1.788	13.35	2.109	93.31	62.39	12.00
2.5	1.263	0.647	1.911	14.57	2.349	93.79	61.75	11.58
5	1.207	0.759	1.966	15.36	2.509	93.71	63.65	11.42
10	1.179	0.714	1.893	15.45	2.330	93.25	61.71	11.38
50	1.191	0.683	1.874	13.45	2.071	93.52	66.13	11.08
(SEM±)	0.0432	0.0506	0.0894	0.661	0.1474	0.2406	1.664	0.441
CD (<0.05)	0.1222	0.1431	0.2529	1.868	0.4166	NS	NS	NS

CD: Critical difference, Sem: Standard error of means, NS: Not significant, Ch A: Chlorophyll a, Ch B: Chlorophyll b, Tot. Ch: Total chlorophyll, FS: Fruit setting, NT/P: Number of trusses per plant, FWC: Fruit water content, Lyco: Lycopene and B. Car: Beta carotene.

increase in fruit set value when compared to Fonaric cultivar which produced the least value (Table 1). Unlike the cultivar effect, the role of applying different doses of the bio-stimulant was found out to be insignificant (Table 1). Contrary to this, the bio-stimulant FOLICIST enhanced plant metabolism leading to improved flowering and fruit set of tomato despite both bio-stimulants having similar mode of action which is related to recovery of plants from metabolic stresses (Ziosi *et al.*, 2012).

Number of trusses per plant

Results of the study indicated in Table 1, showed that number of fruit trusses obtained from the four cultivars of tomato plants was found to be significantly different. The highest numbers of trusses (16.12) were shown in the cultivar Malets recording 112% increase when compared to Fonaric cultivar which resulted into the lowest value number of trusses per plant (7.6). Malets cultivar was observed to exhibit a significantly superior value not only compared to fonaric Cultivar but also with Revansh (11.73) and Talisman (10.19). Such differences are attributed to the genetic differences causing differences in height and number of branches. The number of trusses per plant was not significantly influenced by the albitbr bio-stimulant (Table 1). However, Mallick *et al.* (2024) found significant effect of Bayfolan algae bio-stimulant in increasing the number of tomato trusses because it contains natural stress busters like alginates, mannitol, marine polysaccharides like laminarin and polyphenol.

Number of fruits per truss

The number of tomato fruits per truss obtained from all the four cultivars were found to be significantly different from each other with Malets cultivar producing the highest value (4.323) followed by Talisman (3.558). Malets cultivar possessed 21.5%, 33.9% and 53.7% increase in the number as compared to Talisman, Revansh and Fonaric cultivars respectively (Fig 1). Similarly, application of albitbr bio-stimulant was found to have a significant effect on the number of fruits per truss. The bio-stimulant applied at the dose of 5 L ha^{-1} resulted into the production of the highest number of fruits/truss (3.812) showing 11.5% increase compared to the control attaining 3.421 number of fruits/ truss. The importance of applying the bio-stimulant in relation to this parameter was observed only at 5 L ha^{-1} (Fig 2). In line with results of the present study, Sharma and Chauhan (2019) reported higher number of fruits per cluster (5.67) with the application of triacontanol @ 1.5 mL/L in tomato and the mode of action of these bio-stimulants was found to be similar showing improvement on the tolerance of plants to stresses related to the activities of antioxidant enzymes, such as superoxide dismutase, catalase, peroxidase and those involved in the ascorbate-glutathione cycle (Manai *et al.*, 2024).

Fruit water content

Planting different cultivars and application of albitbr bio-stimulant both did not have significant influence on the water content of tomato fruits (Table 1). In spite of this, the highest numerical value (93.84%) of the fruit water content was shown by Talisman cultivar followed by Fonaric cultivar (93.58%). Water content of tomato fruits was not significantly influenced by the bio-stimulant albit[br].

Lycopene content

Results of the experiment indicated that the lycopene content of tomato cultivars was found to be significantly different (Table 1). Despite the insignificant differences among the three Cultivars; fonaric, malets and Talisman, all of them were found to have significantly higher lycopene values results as compared to the Revansh cultivar that produced the lowest value (12.86 mg 100 g^{-1}). Fonaric cultivar attaining the highest value (14.54 mg 100 g^{-1}) showed a 13.1% increase in lycopene content compared to Revansh. The significant difference is possibly due to the genetic differences for their pest resistance potential

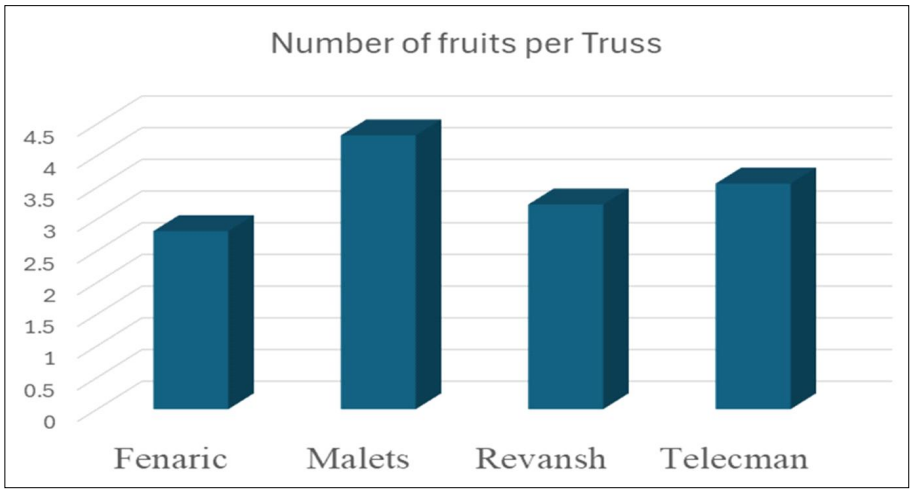


Fig 1: Number of fruits per truss produced by four tomato cultivars.

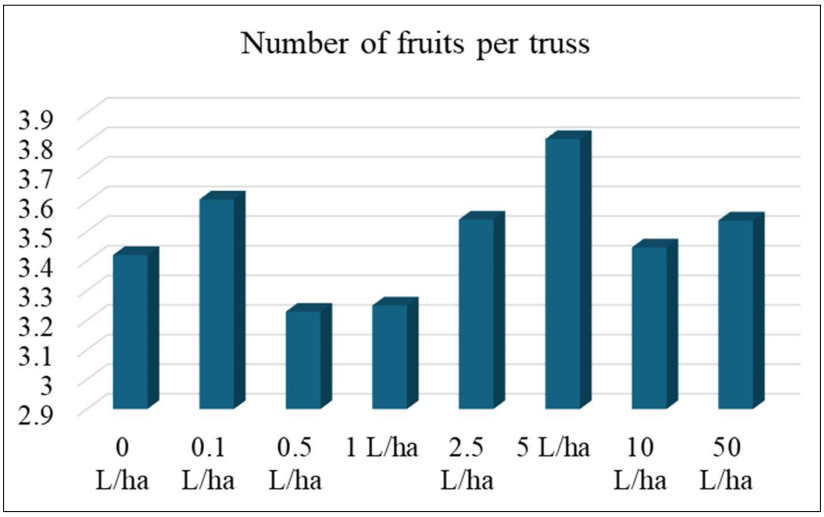


Fig 2: Impact of Albit[br] bio-stimulant on number of fruits per truss.

which was supported by Ikram *et al.* (2022) reporting significant differences in the content of carotenoid pigments. In line with the current results, Vasileva and Nikolai (2021) reported that lycopene composition is determined genotypically. The effect of the albitbr bio-stimulant application was also found to have a significant impact on the lycopene content of tomato fruits (Table 1). The highest value lycopene content (15.45 mg 100 g^{-1}) was recorded from the bio-stimulant dose of 10 L ha^{-1} followed by 5 L ha^{-1} (15.36 mg 100 g^{-1}) and 2.5 L ha^{-1} (14.57 mg 100 g^{-1}) whereas the lowest value was obtained from the 0.5 L ha^{-1} (12.50 mg 100 g^{-1}). Upon comparing all the different doses of the bio-stimulant with the control, only 5 L ha^{-1} and 10 L ha^{-1} showed significantly higher results. Beside this, the lycopene composition obtained from bio-stimulant dose (10 L ha^{-1}) tend to show significant superiority as compared to those obtained from all the other doses with the exception of 5 L ha^{-1} and 2.5 L ha^{-1} doses. Such an improvement is due to sulphate content of bio-stimulants which is closely associated with the increase in lycopene content (Mzibra *et al.*, 2021).

Beta carotene

It was observed that there were significant differences in the values of the beta carotene levels among the cultivars with Fonaric cultivar producing the highest value (2.403 mg 100 g^{-1}) followed by Malets cultivar (14.29 mg 100 g^{-1}) (Table 1). Fonaric cultivar tends to have significantly higher results showing 20.4% and 14.8% increases as compared to Revansh and Talisman cultivars respectively. Apart from fonaric cultivar, the other three cultivars possessed significantly similar results. The significant difference is possibly due to the genetic differences for their pest resistance potential which was supported by Ikram *et al.* (2022) reporting significant differences in content of carotenoid pigments. The role of albitbr bio-stimulant application was also found to be significant where the bio-stimulant applied at the rate of 5 L ha^{-1} led to the production of the highest amount of beta-carotene (2.509 mg 100 g^{-1}) followed by 2.5 L ha^{-1} (2.349 mg 100 g^{-1}) and the lowest value was recorded by 0.5 L ha^{-1} (Table 1). A maximum difference (37.6%) of beta-carotene was recorded upon comparing the values obtained from 5 L ha^{-1} and 0.5 L ha^{-1} albit[br] doses. Plants treated with albitbr at the rate of 5 L ha^{-1} were found to produce significantly better results as compared to 0.5 L ha^{-1}, 50 L ha^{-1} and also the control. The increase in beta carotene is attributed to the effect of the bio-stimulant on improved nutrient absorption and tolerance to abiotic stresses (Kocira *et al.*, 2020).

CONCLUSION

Due the genetic differences of the different cultivars of tomato, statistically different values were noticed among them in all the parameters regarded in the study except in the fruit water content. Fonaric cultivar tends to express the highest significant values of chlorophyll b, total chlorophyll and also both carotenoid pigments. As for the malets Cultivar it led to the production of the highest significant values in the parameters number of trusses per plant, number of fruits per truss. Similar to the cultivar effect, the role of albitbr bio-stimulant also led to the production of fruits with significant differences in all the quality parameters except for fruit water content. Plants treated with 5 L ha^{-1} of the bio-stimulant resulted in the highest significant values of total chlorophyll, chlorophyll b, number of fruits per truss and beta carotene. The highest values of the remaining quality traits like chlorophyll a and lycopene were obtained from 2.5 L ha^{-1} and 10 L ha^{-1} doses of the bio-stimulant respectively. Thus, albitbr doses ranging from 2.5 L ha^{-1} to 10 L ha^{-1} tend to be the best doses for upgrading fruiting potential and quality characteristics of tomato.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

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