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BIO-EFFICACY STUDIES OF BIO STIMULANT (UNIQUE) IN RELATION TO GROWTH, YIELD AND SHELF-LIFE OF THOMPSON SEEDLESS GRAPE VARIETY UNDER MULTILOCATION

R.G. Somkuwar[1]*, Sadashiv Landage[2], P.B. Kakade[3] and N.J. Gobade[1]

[1]ICAR-National Research Centre for Grapes, Pune - 412 307, Maharashtra, India.
[2]Managing Director, Procare Crop Science, Plot No: H-36 M.I.D.C., Kupwad, Sangli - 416 436, Maharashtra, India.
[3]Department of Horticulture, PGI, MPKV, Rahuri - 413 722, Maharashtra, India.
*Corresponding author E-mail : rgsgrapes@gmail.com
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ABSTRACT

A multilocation trial on "Bio-efficacy studies of Unique on growth, yield and shelf-life of Thompson Seedless grapes" was conducted at two locations in Maharashtra (ICAR-NRC for Grapes, Pune and Rahata, Ahmednagar) during 2023-24. Unique, formulated with 30% Diethyl amino ethyl hexonate bioenzyme and aqueous dilution (Q.S.), acts as a potent biostimulant that enhances growth, nutrient balance and crop quality. Three treatments of Unique (20, 25 and 30 ml/L) compared with untreated control were tested via foliar application at five different growth stages. The field experiment was set in a randomized block design with four treatments and five replication per treatment. All the treatment resulted marked improvement in yield, berry quality (size and diameter) and also shelf- life compared to control. The treatment T4 (30 ml/L) resulted into significant increase in bunch weight, berry size and overall yield. In addition, biochemical parameters like phenol, protein and reducing sugar were also significantly increased. However, the foliar application of 30 ml of Unique at five different growth stages was recommended to increase the quality, yield, and shelf life of Thompson Seedless grapes.

Key words : Bio stimulant, Unique, Grapes, Yield, Quality.

Introduction

Grape (*Vitis vinifera* L.) is one of the major important fruit crops covering an area of 1.76 lakh ha which accounts for about 2.5% of the total area under fruit cultivation (2nd Advance Estimate of 2023-24) with the annual production of 38.96 lakh MT and productivity of 22.15 MT/ha (Anonymous, 2024). India is also a leading exporter of fresh grapes having exported 343,982.34 metric tons (MT) of grapes worth ` 3,460.70 crores (equivalent to USD 417.07 million) during 2023-24 (APEDA, 2024). It is considered as one of the richest sources of nutritional components among fruits. Seedless grapes are attracting enormous concern for its good quality and attractive colour. Berry size and sugar to acid ratio is also important in consumer's acceptance (Somkuwar *et al.*, 2023). Considering the berry quality, the major requirement for grape to export is berry diameter and its shelf life. With the problems of soil and water, it is not possible to produce grape berries with desired diameter. Sometimes, even after the application, the weather condition does not support for increase in berry size. Thompson Seedless is a commercially accepted table grape variety in India both for domestic market and also for export (Somkuwar *et al.*, 2024). The environmental factors such as biotic, abiotic and plant nutrition may also influence the economical yield of grape. For better development of vegetative and reproductive stages of plant, various plant growth stimulants as well as crop supplements are being applied to the vine at different growth stages (Sharma *et al.*, 2023; Deshmukh *et al.*, 2023). For years, research in agriculture has focused on improving fruit yield, while little attention was given to produce quality grapes (Somkuwar *et al.*, 2023). Recently, greater importance has been given to environmental protection and production cost reduction, mainly regarding insect pest control as well as foliar nutrition. New formulation, doses and distribution method have been made available in recent years. Bio-stimulant are usually able to improve vigour, stimulate vegetative growth, improve nutrient uptake and distribution within the plant and increase the antioxidant capacity of plant tissues. It has been classified by some researchers as humic substances, amino acids and other nitrogenous compounds, seaweed and plant extracts, chitin and chitosan-like polymers, inorganic compounds, beneficial fungi and beneficial bacteria, waste, exudates and extracts of seeds, leaves and roots (Yilmaz and Sensoy, 2021). Biostimulants are materials that are applied to plants from the leaves, soil or seeds (Bulgari *et al*., 2019). Foliar application requires less amounts of bio stimulants and it also allows for nutrient to be absorbed fast and directly by the leaf (Sharma *et al*., 2023; Deshmukh *et al*., 2023). Unique is a powerful natural biostimulant that enhances plant growth, mitigates stress, balances nutrients and optimizes enzyme activity, resulting in a significant boost in crop yield and quality. Considering the present condition, the research trial was conducted on Bio-efficacy studies of Unique in relation to growth, yield and shelf life of Thompson Seedless grape variety under multilocation trial.

Materials and Methods

Experimental conditions

The trials were conducted at two different locations (ICAR-National Research Centre for Grapes, Pune (18°32′N and 73°51′E) and Rahata (19°42′N and 74°28′E), Ahmednagar district of Maharashtra during the year 2023-24. The experiment was laid out in RBD with four treatments and five replications. Five vine per replication were selected under each replication. In both the locations, the vines were pruned twice in a year; first pruning was done during mid-last week of April, 2023 (foundation pruning) while the second pruning (fruit pruning) was done during mid-last week of October, 2023. Four treatments were imposed by foliar spray during the period of experiment *viz*., T_1- control (water spray), T_2- foliar spray of Unique@ 20 ml/L, T_3 - foliar spray of Unique@ 25 ml/L and T_4 - foliar spray of Unique@ 30 ml/L at five different stages (1st - After 12 to 13 days of fruit pruning, 2nd After 23 to 25 days of fruit pruning, 3rd on 75 to 100% flowering stage, 4th on 100% setting of fruits stage (2 mm Berry Size) and 5th after 8 to 10 days (100% setting of fruits stage). Water volume used for spray was based on the canopy size (250 to 400 L/acre).

Growth parameters

Shoot length was measured from the 1st node at 90 days after fruit-pruning and expressed in cm. Shoot diameter between the fifth and sixth nodes was measured using a Vernier calliper, averaged for five canes per vine and expressed in mm. Leaf area was calculated using the formula: Leaf area (A) = L × B × K (0.810) and expressed in cm².

Bunch and yield parameters

The mean number of bunches per vine were calculated from five selected vines after berry set. Similarly, the average number of berries per bunch was determined from five bunches per treatment. The mean bunch weight was recorded by averaging 10 bunches from five randomly selected vines at harvest. Berry weight was calculated from 50 randomly selected berries. Grapes were harvested at proper maturity and yield was recorded.

Berry Quality Parameters

Ten randomly selected berries per replication were used to measure length and diameter using a Vernier caliper (mm). Juice was extracted from these berries to determine total soluble solids (°Brix) using a hand refractometer. Titratable acidity (%) was measured by titrating the juice with 0.1 N NaOH. Chlorophyll content in leaves was estimated using the DMSO method.

Biochemical Parameter

The Folin-Ciocalteu method (Singleton and Rossi, 1965) was used to estimate phenols, expressed in mg/g. Soluble protein content in grape berries was measured using Lowry's method (1951) and expressed in mg/g. Reducing sugars in grape berries were determined by DNSA method (Miller, 1972) and expressed in percentage. Calcium (ppm) was measured using the neutral normal ammonium acetate method, while phosphorus content in petiole samples was determined using the Venadomolybdo phosphoric acid method (Jackson, 1973) with absorbance at 470 nm on a spectrophotometer.

Physical properties of treated grapes

Pedicel thickness was measured with a vernier caliper and expressed in mm. The skin thickness of ten randomly selected grape berries was measured using a portable digital caliper micrometer. To assess physical changes during storage, physiological loss in weight (PLW) was calculated as the percentage of mass lost over time. Each treatment's mass was recorded daily for 5 days to determine PLW (%) at each interval was calculated as:

Physiological loss in weight (%)

$$= \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Statistical analysis

Statistical analysis of data collected during the experiment was analyzed by using Randomized Block Design (RBD) of standard method of analysis of variance as described by Panse and Sukhatme (1995).

Results and Discussion

The data recorded on various growth parameters of grapes is presented in Table 1. In both the locations, statistically significant variation was found for shoot length, diameter and leaf area between different concentration of Unique. However, the treatment T_4 showed highest shoot length (102.00 cm) and maximum shoot diameter (7.05 mm) whereas treatment T_2 showed lowest shoot length (90.00 cm) and minimum shoot diameter in T_1 (6.62 mm). Leaf area (cm^2) varied significantly among the different concentrations of Unique over the untreated control. At 90 days after fruit pruning, leaf area was higher in T_2 and T_4 (170.00 cm^2), which was followed by T_3 (165.00 cm^2) over the control treatment T_1 (150.00 cm^2) at ICAR-NRCG. However, at Rahata the treatment T_4 recorded higher shoot diameter of 8.45 mm as compared to the lowest in T_1 (7.25 mm). The leaf area also varied significantly among the different treatments. The treatment T_4 recorded highest leaf area of 174.53 cm^2 followed by T_3 (170.50 cm^2) as compared to the control T_1 (160.50 cm^2). Among the different treatments of Unique, there was not much difference in shoot growth. An increase in shoot length and diameter directly affects grape productivity by influencing photosynthesis and nutrient allocation. As shoot length increases, more photosynthetic products are used for shoot growth, reducing the resources available for cane development and fruit growth (Somkuwar *et al*., 2024). Optimal shoot growth enhances berry composition and size, leading to better overall grape quality (Somkuwar *et al*., 2024d). However, excessive vegetative growth can negatively impact yield and quality by diverting resources away from reproductive parts. Maintaining an optimal leaf area is crucial for improving grapevine yield and quality, as it boosts carbohydrate production (Somkuwar *et al*., 2024a; 2024b; 2024c). Additionally, shoot length and diameter are correlated with higher pruning weights and total biomass accumulation, further contributing to productivity (Somkuwar *et al*., 2024d).

Bunch and yield parameters

The data recorded on number of bunches/vines, number of berries/bunches, average bunch weight (g), 50-berry weight and yield/vine are presented in Table 2. Application of Unique had non-significant effect on number of bunches/vine and number of berries per bunch. This was mainly because the fruit bud differentiation was already been completed during the period of 40 to 70 days after the foundation pruning. In addition, considering the quality yield for export purpose, bunch thinning was also done after berry set. Treatment T_4 significantly showed highest average bunch weight (474.82 g), 50 berry weight (143.10 g) and yield/vine (16.35 kg), which was at par with the treatment T_3 (459.26 g, 138.20 g, 15.88 kg respectively) over the control treatment T_1 (334.12 g, 122.60 g, 11.36 kg respectively) at ICAR-NRCG. A more or less similar trends with different values was also recorded at Rahata. The application of Unique led to notable physiological improvements in grapevines, particularly increasing average bunch weight, 50-berry weight and overall yield. Additionally, biostimulants such as seaweed extracts and humic acids have been demonstrated to enhance nutrient uptake by grapevines either directly or indirectly (Nardi *et al*., 2016). These enhancements in nutrient availability combined with improved physiological responses contributed to higher yield (Shahrajabian *et al*., 2021; Irani *et al*., 2021). The yield increase was primarily due to the larger size, weight of the bunches and grape berries, which likely improved carbon assimilation efficiency through enhanced

Table 1 : Effect of Unique on growth parameters of Thompson Seedless grapes.

Treatments	Pune location			Rahata location		
	Shoot length (cm)	Shoot diameter (mm)	Leaf area (cm^2)	Shoot length (cm)	Shoot diameter (mm)	Leaf area (cm^2)
T_1- Control	95.40	6.62	150.00	90.20	7.25	160.50
T_2- Unique @ 20 ml	90.00	6.73	170.00	98.50	8.08	165.52
T_3- Unique @ 25 ml	100.00	6.87	165.00	96.30	8.12	170.50
T_4- Unique @ 30 ml	102.00	7.05	170.00	95.40	8.45	174.53
CD at 5%	2.30	0.28	4.05	2.34	0.20	4.03
Sig	**	*	**	**	**	**

Table 2 : Effect of Unique on bunch and yield parameters of Thompson Seedless grapes.

Treatments	No of bunches/ vine	No of berries/bunch	Average bunch weight (g)	50 berry weights (g)	Yield/vine (kg)
Pune location					
T_1- Control	34.00	114.40	334.12	122.60	11.36
T_2- Unique @ 20 ml	33.60	113.60	358.52	129.10	12.05
T_3- Unique @ 25 ml	34.60	113.80	459.26	138.20	15.88
T_4- Unique @ 30 ml	34.40	112.80	474.82	143.10	16.35
CD at 5%	1.40	7.89	53.24	14.28	2.11
Sig	NS	NS	**	*	**
Rahata location					
T_1- Control	30.25	115.00	380.50	165.44	11.53
T_2- Unique @ 20 ml	32.56	116.50	430.25	184.67	14.04
T_3- Unique @ 25 ml	33.40	117.00	465.50	198.95	15.62
T_4- Unique @ 30 ml	33.85	119.00	515.45	216.59	17.46
CD at 5%	2.72	2.74	11.23	1.16	0.79
Sig	NS	NS	**	**	**

Table 3 : Effect of Unique on berry quality parameters of Thompson seedless grapes.

Treatments	Berry length (mm)	Berry diameter (mm)	TSS (°Brix)	Acidity (%)
Pune location				
T_1- Control	19.31	17.05	18.08	0.61
T_2- Unique @ 20 ml	19.94	17.08	18.18	0.62
T_3- Unique @ 25 ml	20.47	18.02	18.40	0.64
T_4- Unique @ 30 ml	20.79	18.04	18.20	0.63
CD at 5%	0.49	0.43	0.61	0.015
Sig.	**	**	NS	**
Rahata location				
T_1- Control	20.02	17.80	17.80	0.55
T_2- Unique @ 20 ml	21.15	18.40	18.00	0.59
T_3- Unique @ 25 ml	22.50	19.20	18.20	0.54
T_4- Unique @ 30 ml	22.80	20.40	18.20	0.52
CD at 5%	0.55	0.45	0.43	0.013
Sig.	**	**	NS	**

photosynthesis and protein synthesis, a result of biostimulant application (Deshmukh *et al.*, 2023). The observed improvements in bunch weight and overall yield with unique treatments could be attributed to the biostimulants' ability to modify molecular processes that improve water and nutrient use efficiency, promote plant development and mitigate abiotic stress (Van oosten *et al.*, 2017) by stimulating both primary and secondary metabolism (Rao *et al.*, 2016). Secco *et al.* (2016) also reported the highest increases in berry and bunch weight. Significant yield improvement using biostimulant in grape varieties such as Thompson Seedless and Sharad Seedless were reported by Sharma *et al.* (2023) and Deshmukh *et al.* (2023).

Berry quality parameters

The grape quality mainly consists of berry length, berry diameter, TSS and acidity. Berry length and berry diameter varied significantly among the different treatments (Table 3). The treatment T_4 recorded highest berry length (20.79 mm) which was at par with the treatment T_3 (20.47 mm) compared to untreated control T_1 (19.31 mm). Berry diameter varied significantly among the different concentrations of Unique over the untreated control. Berry diameter was higher in T_4 (18.04 mm) which was at par with the treatment T_3 (18.02 mm) compared to the control treatment T_1 (17.05 mm). Different concentrations of Unique showed non-significant variation in TSS of grape berries (Table 3), however, TSS ranged from 18.08°Brix (T_1) to 18.40°Brix (T_3). The acidity ranged from 0.61 % in T_1 to 0.64% in T_3 treatment. The acidity in grape berries was within the acceptable limit in all the treatments at ICAR-NRCG. Though the trend was generally similar, different values were recorded at Rahata. Bio stimulants, such as protein hydrolysates and humic substances, have been shown to

Table 4 : Effect of Unique on chlorophyll content in leaf of Thompson Seedless grapes.

Treatments	45 Days after fruit Pruning			90 Days Fruit Pruning		
	Chlorophyll a (ug/ml)	Chlorophyll b (ug/ml)	Total chlorophyll (ug/ml)	Chlorophyll a (ug/ml)	Chlorophyll b (ug/ml)	Total chlorophyll (ug/ml)
Pune location						
T_1- Control	8.27	2.82	11.09	13.94	4.29	18.23
T_2- Unique @ 20 ml	9.63	3.06	12.69	14.54	4.05	18.59
T_3- Unique @ 25 ml	8.70	2.71	11.41	11.95	2.89	14.84
T_4- Unique @ 30 ml	11.14	3.07	14.21	12.15	3.46	15.61
CD @ 5%	0.93	0.43	0.97	1.45	0.64	1.87
Sig	**	NS	**	**	**	**
Rahata location						
T_1- Control	9.52	3.46	12.98	11.45	4.86	16.31
T_2- Unique @ 20 ml	9.86	4.51	14.37	13.62	4.75	18.37
T_3- Unique @ 25 ml	10.25	3.68	13.93	15.23	6.24	21.47
T_4- Unique @ 30 ml	11.83	4.78	16.61	17.48	7.10	24.58
CD @ 5%	0.23	0.08	0.31	0.38	0.15	0.53
Sig	**	**	**	**	**	**

significantly increase berry size. Research indicated that berries treated with these biostimulants exhibit greater length and diameter compared to untreated controls (Nardi *et al*., 2016; Shahrajabian *et al*., 2021). This increase in berry size is likely due to the stimulation of cell division and elongation triggered by the application of bio stimulants (Warusavitharana *et al*., 2008; Deshmukh *et al*., 2023). Since both berry length and diameter are key factors determining berry shape, these findings align with the results of Sharma *et al*. (2023), who also reported that bio-stimulant significantly enhanced berry size over control treatments. However, at harvest, no significant effects on total soluble solids (TSS) were observed as also noted by Frioni *et al*. (2019) and Sharma et al. (2023). Similarly, Deshmukh *et al*. (2023) reported a non-significant effect of biostimulants on TSS, but significant impact on titratable acidity.

Chlorophyll content in leaf

The data recorded on leaf chlorophyll content at 45 and 90 days after fruit pruning of grapes is presented in Table 4. The differences for chlorophyll a content in the grape leaf varied significantly among the different treatments. During 45 days after fruit pruning, the higher chlorophyll a content in grape leaf was recorded in T_4 (11.14 ug/ml) followed by T_2 (9.63 ug/ml) as compared to T_1 (8.27 ug/ml). The differences for chlorophyll b were non-significant only at Pune location. Total chlorophyll content was higher in T_4 (14.21 ug/ml) followed by T_3 (12.69 ug/ml) as compared to control T_1 (11.09 ug/ml). The chlorophyll content after 90 days of fruit pruning varied significantly among the different treatments. The treatment T_2 recorded higher total chlorophyll content (18.59 ug/ml) followed by T_1 (18.23 ug/ml) while the T_3 recorded lowest concentration (14.84 ug/ml) at ICAR-NRCG. However, similar pattern but with different values at 45 days after fruit pruning was observed at Rahata. While, similar trend was observed after 90 days after the fruit pruning with higher concentration in T_4 (24.58 ug/ml) followed by T_3 (21.47 ug/ml) as compared to control T_1 (16.31 ug/ml). The increase in chlorophyll content in Unique-treated plants can be attributed to improved nutrient absorption and enhanced physiological conditions. These improvements lead to healthier leaves and increased photosynthetic efficiency, facilitating the transfer of sugars and starches, while also activating key enzymes involved in chlorophyll synthesis. As a result, treated plants exhibit higher overall chlorophyll levels (Bhattacharya *et al*., 2015; Sharma *et al*., 2023). Additionally, the rise in chlorophyll content is linked to a reduction in its degradation and an improvement in chloroplast biogenesis. Previous studies have shown that one of the key effects of biostimulant treatment is the increased chlorophyll content in treated plants, as noted by Bhattacharyya *et al*. (2015) and Sharma *et al*. (2023).

Biochemical parameters in grape berries

The data recorded on various biochemical parameters (phenol, protein, reducing sugar, calcium), phosphorus (%) at full bloom and at veraison stage is presented in Table 5. Statistically non-significant variation was found in phosphorus content (%) at veraison stage. Phenol was relatively higher in T_3 (0.56 mg/g), while it was lowest in T_2 (0.42 mg/g). The maximum protein was recorded in T_4 (16.08 mg/g) which was at par with T_3 (16.01 mg/g) while minimum protein was observed in T_1(12.05 mg/g). Reducing sugar varied significantly among the different treatments studied. The treatment T_4 recorded highest reducing sugar (350.00 mg/g) followed by T_3 (331.00 mg/g), whereas T_2 showed lowest reducing sugar (228.00 mg/g). The maximum calcium was recorded in T_4 (48.01 ppm) followed by T_2 (45.10 ppm) and T_3 (38.01 ppm) while minimum calcium content in grape berries was recorded in control T_1 (36.80 ppm). Phosphorus (%) at full bloom stage varied significantly among the different treatments. The treatment T_4 recorded highest phosphorus content in petiole (0.563%), which was at par with T_3 (0.535), whereas T_1 showed lowest phosphorus content (0.519%). The same trend was also recorded for phosphorus content in petiole at veraison stage at ICAR-NRCG. The comparable trend, though the values varied, was documented in Rahata except higher phenol content in T_4 (0.60 mg/g), while it was lowest in T_1 (0.48 mg/g). There was positive correlation between phosphorus (%) and % fruitful canes in grapevine. Phenolic compounds are a crucial class of plant metabolites involved in a wide range of physiological processes, making them essential for plant health and development (Martínez-Lorente *et al*., 2024). Research indicated that the use of biostimulants can significantly increase the accumulation of phenolic compounds in various plant tissues, including fruits, leaves and roots, across numerous crops (Martínez-Lorente *et al*., 2024). This enhancement in phenolic content plays a key role in supporting fruit maturation, maintaining sugar levels and boosting the concentrations of beneficial compounds such as anthocyanins and polyphenols (Salvi *et al*., 2016). Among various bio stimulants, seaweed extracts have shown particular effectiveness in enhancing phenolic content in grapevines which is essential for improving fruit quality and antioxidant properties (Irani *et al*., 2021). These extracts stimulate key enzymes involved in phenolic metabolism resulting in a marked increase in phenolic concentrations in grape berries (Nardi *et al*., 2016). Additionally, biostimulant contribute to optimize nitrogen metabolism, a fundamental process in protein synthesis. Enhanced nitrogen availability, especially during the bloom phase has been associated with higher protein levels in plant tissues (Shahrajabian *et al*., 2021). Protein hydrolysates, a type of biostimulant, are particularly effective at supplying amino acids, directly supporting protein synthesis in grapevines (Nardi *et al*., 2016). Bio stimulants also play a significant role in promoting sugar accumulation in grapevines, particularly under stress conditions. For example, seaweed extracts have been shown to increase total soluble solids (TSS), including reducing sugars, in grapevines subjected to drought stress (Irani *et al*., 2021). The interplay between nitrogen availability and light exposure during the veraison phase is critical for sugar accumulation, with biostimulants helping to regulate these factors, leading to improved sugar levels during this vital stage of development (Sharma *et al*., 2023). In terms of mineral uptake, biostimulants contribute to better grape quality by increasing berry weight and reducing acidity (Irani *et al*., 2021). Seaweed extracts and humic substances in particular, promote root hair development, improving the absorption of essential nutrients such as calcium and phosphorus (Nardi *et al*., 2016; Irani *et al*., 2021). Phosphorus is a key nutrient for plants, facilitating energy transfer through the formation of ATP and other nucleotide

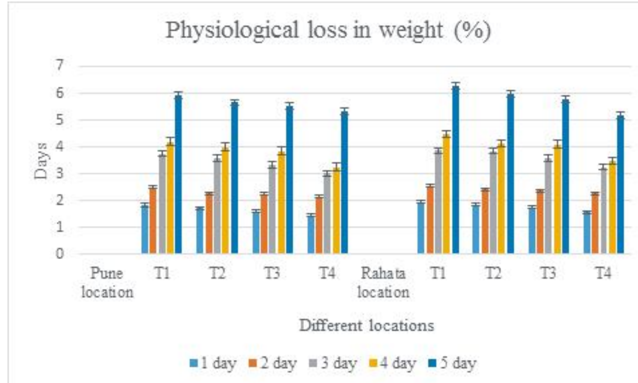

Fig. 1 : Effect of Unique on physiological loss in weight (%) of Thompson Seedless grapes.

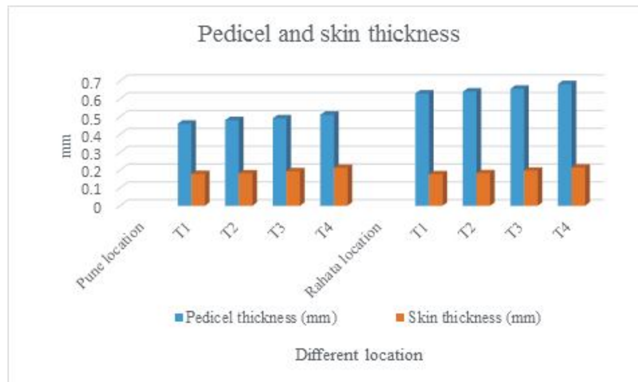

Fig. 2 : Effect of Unique on pedicel thickness (mm) and skin thickness (mm) of Thompson Seedless grapes.

Table 5 : Effect of Unique on biochemical parameters of Thompson Seedless grapes.

Treatments	Phenol mg/g	Protein mg/g	Reducing sugar mg/g	Calcium (ppm)	Phosphorus (%) full bloom	Phosphorus (%) at veraison
Pune location						
T_1- Control	0.48	12.05	310.00	36.80	0.519	0.303
T_2- Unique @ 20 ml	0.42	14.08	280.00	45.10	0.529	0.305
T_3- Unique @ 25 ml	0.56	16.01	331.00	38.01	0.535	0.310
T_4- Unique @ 30 ml	0.55	16.08	350.00	48.01	0.563	0.316
CD at 5%	0.06	0.42	7.39	1.83	0.03	0.014
Sig	**	**	**	**	**	NS
Rahata location						
T_1- Control	0.48	14.05	260.50	36.80	0.512	0.305
T_2- Unique @ 20 ml	0.49	15.10	262.45	38.01	0.540	0.315
T_3- Unique @ 25 ml	0.58	16.20	240.80	45.10	0.545	0.321
T_4- Unique @ 30 ml	0.60	17.00	265.80	48.01	0.559	0.328
CD at 5%	0.014	0.39	5.32	1.36	0.014	0.011
Sig	**	**	**	**	**	**

triphosphates. It is essential for the synthesis of critical molecules such as sucrose, phospholipids, cellulose and nucleic acids (DNA and RNA), which are crucial for maintaining the structural integrity and functionality of the protoplasm, nucleus and cell walls. Phosphorus's mobility within the plant allows for its efficient translocation, ensuring that it reaches all parts of the plant to sustain essential cellular activities (El-Boray *et al*., 2007). Proper nutrient absorption, especially of phosphorus and calcium, is vital for healthy plant growth as these nutrients are required to produce essential metabolites and enzymes and serve as cofactors in various physiological processes. Numerous studies have shown that biostimulants can significantly enhance the uptake of phosphorus (P) and calcium (Ca) in fruit crops promoting better growth and higher yields (Martínez-Lorente *et al*., 2024).

Shelf life

In all the treatments, the PLW (%) increased with the advancement in storage duration. The minimum physiological loss in weight (%) was recorded in treatment T_4 from 1st day (1.46%), 2nd day (2.16%), 3rd day (3.02%), 4th day (3.25%) and 5th day (5.33%). The physiological loss in weight (%) in grape berries of control treatment increased rapidly from 1st day (1.84%), 2nd day (2.50%), 3rd day (3.74%), 4th day (4.20%) and 5th day (5.94%) at ICAR-NRCG. The similar trend, yet with variations in values was recorded at Rahata. Pedicel thickness was relatively higher in T_4 (0.510 mm), while it was lowest in T_1 (0.460 mm). The treatment T_4 recorded maximum skin thickness (0.212 mm) while it was minimum in T_1 (0.178 mm) at ICAR-NRCG. A similar trend was documented at Rahata except, skin thickness. The results of the present study indicated the importance of use of Unique in improving berry quality of grapes. The increased thickness of the pedicel and grape skin plays a crucial role in enhancing the storage life of grape bunches. Deshmukh *et al.* (2023) similarly observed that grapevines treated with biostimulants developed thicker skins, resulting in a longer shelf life compared to untreated grapes. The application of biostimulants may initiate lipid peroxidation processes and activate defense-related enzymes which help to maintain the firmness of grape berries. This leads to reduced fruit drop, minimized physiological weight loss and prevention of berry decay during storage (Liu *et al*., 2016; Zaharah *et al*., 2012; Deshmukh *et al*., 2023; Sharma *et al*., 2023).

Conclusion

A field experiment on the Bio-efficacy of Unique under multilocation trial was conducted during 2023-24 in two different locations (ICAR-NRC for Grapes, Pune and Rahata, Ahmednagar). Unique treatments significantly enhanced grape yield, berry quality and shelf life compared to control in both the locations. The treatment T_4 (30 ml/l) showed the best results for improving bunch and berry quality, shelf life and overall yield in Thompson Seedless grapes. Therefore, applying 30 ml of Unique at these critical stages is recommended for yield and quality of grapes.

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