**Bio-efficacy studies of Budmaker in relation to growth, yield and shelf-life of Nanasaheb Purple Seedless grape under multilocation**

**Abstract**

The study aimed to assess the bio-efficacy of Budmaker on fruit yield, quality, leaf mineral content and key physio-chemical characteristics of the grapevine (*Vitis vinifera* L.) cv. Nanasaheb Purple Seedless. A multilocation trial was conducted in 2023-24 at two sites: ICAR-National Research Centre for Grapes, Pune, and a farmer's field in Walwa, Sangli, Maharashtra. Budmaker was applied in different doses at three stages: first at the 1st leaf after sub-cane emergence, then at the 3rd and 4th leaves and finally at the 6th and 7th leaves. The concentrations tested were 400, 500 and 750 ml/acre. Among these treatments, the application of 500 ml/acre significantly enhanced vegetative growth, including pruned biomass, fruitfulness percentage and early cane maturity. Improvements were also observed in yield parameters such as average bunch weight, 50-berry weight, yield per vine, berry size and chlorophyll content. Additionally, biochemical and nutrient content, including phenol, protein, reducing sugars, calcium, phosphorus and other quality traits such as physiological loss in weight (PLW), pedicel and skin thickness, showed positive response. The bio stimulant Budmaker (500 ml/acre) proved effective in improving the yield and quality of Nanasaheb Purple Seedless grapes under multilocation trial.

**Keywords:** Budmaker, grapevine, yield, quality, shelf life

**Introduction**

Grapevines (*Vitis vinifera* L.) originally native to temperate regions have been successfully adapted for commercial cultivation in tropical climates across various countries due to technological advancements and the inherent flexibility of the plant. In tropical regions, grape production is primarily focused on table grapes, with India emerging as a major producer. In the domestic and export markets, consumers preferred table grapes based on the qualitative traits viz, bunch size, berry shape, skin colour, skin thickness, flesh hardness, internal quality, flavour, aroma and sugar: acid ratio (Deshmukh et al., 2023). Grape is a high value crop in the country, known for their high productivity and source of high-income generation for farmers. According to second advanced estimate, in India, grape cultivation is on approximately 176,000 hectares producing around 3.89 million tons of grapes in the 2023-24 season (Anonymous, 2024). Maharashtra leads the country in both area and production followed by Karnataka, Tamil Nadu, Mizoram and parts of northern India. About 69% of India’s grape production is dedicated to table grapes, 29% to raisin production and the remainder is processed into wine and juice. Maharashtra alone accounts for 81% of India’s grape production, with an average yield of 22-25 tons per hectare (Sharma et al., 2023). Being a coloured table grape with high berry quality, Nanasaheb Purple Seedless is among the most popular in Maharashtra and Karnataka, widely cultivated for both domestic consumption and export (Somkuwar et al., 2024c). In tropical regions, sustainable grape production faces several challenges, such as high temperatures, limited water availability and poor soil quality. Among these, temperature is a critical factor influencing the growth, development, yield and quality of grapevines. Nowadays growers turned their focus to sustaining production and improving berry quality using bio stimulants to boost metabolic activity and regulate growth during vegetative and reproductive stages in the grapevine (Deshmukh et al., 2023). Bio-stimulants are biological products designed to improve plant growth, vigor and resilience by enhancing nutrient uptake and improving physiological functions. These products are derived from various organic sources, including seaweed extracts, humic substances, industrial residues, beneficial fungi, rhizobacteria and protein hydrolysates. Ascophyllum nodosum, a marine plant commonly used as a bio-stimulant, has been widely applied in grapevine cultivation (Norrie et al., 2001). Seaweed-based bio-stimulants are rich in essential nutrients, such as micro and macronutrients, auxins, cytokinins, abscisic acid (ABA)-like compounds, amino acids, sugars, vitamins and betaines, which help plants manage stress more effectively (Khan et al., 2009; Minocha et al., 2014; Saa et al., 2015). Hydrolyzed proteins, composed of free amino acids and peptides are another key category of bio-stimulants. Derived through chemical or enzymatic processes they positively influence plant growth by improving nutrient absorption and physiological functions (Salvi, 2016; Van Oosten, 2017). Foliar application of bio-stimulants not only promotes plant growth but also enhances nutrient uptake offering an environmentally friendly alternative to soil fertilization by preventing nutrient leaching into ground water. In grapevines, especially under stress conditions, seaweed extracts have been shown to improve chlorophyll content, yield and berry weight (Sabir et al., 2014). They also enhance nutrient efficiency, leading to improved sugar content, higher sugar-to-acid ratios, increased cluster weight and volume and overall yield, as demonstrated in Thompson Seedless grapes (El-Borray et al., 2007; Yakhin et al., 2017). However, the effectiveness of bio-stimulants can vary depending on factors such as the type of compound used, application rate, timing, number of treatments and the grape variety (Gutiérrez-Gamboa et al., 2018). In response, an experiment was conducted to evaluate the effects of Budmaker (a biostimulant) application on regulating the yield and quality of Nanasaheb Purple seedless grapes through a multilocation trial.

**Material and Methods**

**Experimental conditions**

 The experimental trials were conducted at two locations (ICAR-National Research Centre for Grapes, Pune (18°32ʹN, 73°51ʹE) and a farmer's plot in Walwa (19°42ʹN, 74°28ʹE) in Sangli, Maharashtra) during 2023-24. The grape variety Nanasaheb Purple Seedless was selected for the experiment at both sites. The trial followed a randomized block design (RBD) with four treatments and five replications per treatment, each replication consisting of five vines. Pruning was performed twice a year at both locations: foundation pruning in the last week of April 2023 and forward pruning in the last week of October 2023. The treatments included: T1 (control), T2 (foliar application of Budmaker at 400 ml/acre), T3 (foliar application of Budmaker at 500 ml/acre) and T4 (foliar application of Budmaker at 750 ml/acre). Budmaker was applied as a foliar spray at three growth stages (at one leaf stage after sub-cane development, at 3rd and 4th leaf stages after sub-cane development and at 6th and 7th leaf stages after sub-cane development). The water volume for the foliar spray ranged from 250 to 400 L/acre, depending on the canopy size.

**Growth Parameters**

 Shoot length was measured at 90 days after foundation pruning and expressed in cm. Shoot diameter was measured between the fifth and sixth node using a Vernier caliper on five canes per vine at 90 days after foundation pruning from five vines, with the mean expressed in millimeters. Leaf area was calculated using the linear LBK method, expressed in cm², based on the formula: Leaf area (A) = L x B x K (0.810) (Ghule et al., 2019). Pruned biomass was collected from each vine immediately after pruning, weighed and the mean weight was expressed in kg/vine. The percentage of fruitful canes was computed based on the number of total canes and the number of fruitful canes. Days to cane maturity were calculated from the date of foundation pruning to cane maturity and the mean was recorded.

**Bunch and Yield Parameters**

 The total number of bunches was counted from five selected vines in each treatment and the mean number of bunches per vine was calculated after berry set. The total number of berries was counted from five selected bunches and the mean number of berries per bunch was determined. The mean bunch weight was recorded by averaging the weight of 10 bunches randomly selected from five vines at harvest, expressed in grams. Berries from five vines were randomly collected at harvest and the mean berry weight was calculated from 50 berries, expressed in grams. Yield was recorded at harvest and expressed in kg after reaching maturity based on TSS and acidity.

**Berry Quality Parameters**

 Berry length and diameter were measured on 10 randomly selected berries per replication using a Vernier caliper. Total soluble solids (TSS) in the juice were measured using a hand refractometer and expressed in °Brix. Total titratable acidity was determined by titrating berry juice with 0.1 N NaOH and expressed as a percentage.

**Biochemical Parameters**

 Chlorophyll content in leaves was estimated using the Dimethyl sulfoxide (DMSO) method. Phenol content was measured using the Folin-Ciocalteu method (Singleton and Rossi, 1965) and expressed in mg/g. Fruit soluble protein content at harvest was estimated by the Lowry method (1951) and expressed as milligrams per gram of fresh weight (mg/g). The percentage of reducing sugars in the grape berries was determined using the Dinitro-Salicylic acid (DNSA) method (Miller, 1972) and expressed as a percentage. Calcium (ppm) was estimated using the neutral normal ammonium acetate method from diacid extract, while phosphorus content (%) in petiole samples was estimated using the Venadomolybdo phosphoric acid yellow colour method, with the intensity of the yellow colour measured at 470 nm using a double beam spectrophotometer (Jackson, 1973).

**Physical properties of treated grapes**

 The thickness of the pedicel was measured using a vernier caliper and expressed in millimeters (mm). The skin of ten randomly selected berries was peeled using a laser blade and the thickness was measured with a mini portable digital caliper micrometer. Skin thickness was also recorded in mm. To assess changes in the physical properties of treated grapes during storage, physiological loss in weight (PLW) was measured as described by Sharma et al. (2023). Shelf-life, in terms of PLW (%), was calculated as the percentage of mass lost by the bunch from the beginning to the end of the shelf-life period. The mass of each treatment was recorded daily for 5 days, and PLW (%) at each interval was calculated as follows: $Physiological loss in weight (\%)=\frac{Initial weight-Final weight}{Initial weight }×100$

**Statistical analysis**

 Statistical analysis of data collected during the experiment was analysed by using Randomized Block Design (RBD) of standard method of analysis of variance as described by Panse and Sukhatme (1985).

**Result and Discussion:**

**Growth parameters**

       The data recorded on growth parameters of grapes is presented in Table 1. Significant variation was recorded in shoot length, shoot diameter, leaf area, pruning biomass, percent fruitful canes and days taken to cane maturity with different concentrations of Budmaker across the locations. Treatment T1 recorded highest shoot length (87.00 cm) and shoot diameter (7.80 mm) which was followed by T2 (85.00 cm and 7.50 mm respectively), whereas T3 showed minimum shoot length (83.00 cm and 7.32 mm respectively). The maximum leaf area (163.00 cm2) was recorded in T3, while minimum in T1 (155.50 cm2). The reduced shoot length is beneficial for higher fruitfulness in grapes. During October pruning, pruned biomass was highest in treatment T1 (0.87 kg) while its was lowest in T4 (0.83 kg). Early cane maturity was recorded in T3 (107.29) which was followed by T4 and T2 (110.00 and 110.30 respectively) whereas treatment T1 (Control) recorded more days to cane maturity (112.01) at Pune. A comparable pattern, albeit with variable data, was observed at Walwa in Maharashtra's Sangli district. Except, higher % fruitful canes (80.00%) were recorded in T3 treatment followed by T1 (78.00%) and T4 (77.0%). An increase in shoot length and diameter influences grape productivity by affecting photosynthesis and nutrient allocation, where optimal growth enhances berry composition and size, leading to better overall grape quality (Somkuwar et al., 2024d). However, excessive growth can negatively impact yield and quality by diverting resources. Only an optimal leaf area positively impacts grapevine yield and quality by improving carbohydrate production (Somkuwar et al., 2024a; 2024b; 2024c). Shoots length and diameters correlate with higher pruning weights and total biomass (Somkuwar et al. 2024d). The use of biostimulants can lead to a higher number of fruitful canes, as they stimulate metabolic processes that enhance flowering and fruit set (Shahrajabian et al., 2021; Irani et al., 2021).

**Table 1: Effect of Budmaker on growth parameters of Nanasaheb Purple Seedless grapes**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Foundation pruning (90 Days) | October pruning |  |
| Shoot length(cm) | Shoot diameter (mm) | Leaf area (cm2) | Pruned biomass (kg/vine) | Fruitful canes(%) | Days taken to cane maturity |
| Pune location |
| T1- Control | 87.00 | 7.80 | 155.50 | 0.87 | 73.00 | 112.01 |
| T2- Budmaker @ 400 ml/L | 85.00 | 7.50 | 158.50 | 0.85 | 74.00 | 110.30 |
| T3- Budmaker @ 500 ml/L | 83.00 | 7.32 | 163.00 | 0.84 | 75.00 | 107.29 |
| T4- Budmaker @ 750 ml/L | 83.10 | 7.50 | 162.60 | 0.83 | 74.60 | 110.00 |
| CD at 5% | 1.94 | 0.19 | 3.89 | 0.02 | 1.78 | 2.62 |
| Sig | \*\* | \*\* | \*\* | \*\* | NS | \* |
| Walwa location |
| T1- Control | 85.00 | 8.00 | 160.00 | 0.65 | 78.00 | 115.01 |
| T2- Budmaker @ 400 ml/L | 80.00 | 7.80 | 163.00 | 0.63 | 76.00 | 112.00 |
| T3- Budmaker @ 500 ml/L | 78.00 | 7.08 | 170.00 | 0.62 | 80.00 | 110.00 |
| T4- Budmaker @ 750 ml/L | 78.00 | 7.60 | 167.00 | 0.62 | 77.00 | 108.01 |
| CD at 5% | **1.80** | **0.16** | **4.11** | **0.02** | **1.93** | **2.58** |
| Sig | **\*\*** | **\*\*** | **\*\*** | **\*** | **\*\*** | **\*\*** |

**Bunch and yield parameters**

The data recorded on bunch, berry parameters and yield/vine are presented in Table 2. The differences for number of bunches/vine and number of berries/bunch were non-significant. This was mainly due to the fact that 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 is also done after berry set. The treatment T3 significantly recorded highest average bunch weight (550.20 g), 50-berry weight (357.34 g) and yield/vine (16.90 kg) which was followed by T4 (530.60 g, 341.22 g and 15.39 kg respectively) over the control T1 (470.10 g, 301.39 g, 14.13 kg respectively) at ICAR-NRCG. Similar trends, though differing in values, were also noted in Walwa, Sangli district of Maharashtra. The application of Budmaker lead to physiological improvements that significantly enhanced grapevine performance, particularly in terms of average bunch weight, 50-berry weight, and overall yield. Additionally, biostimulants such as seaweed extracts and humic acids have been shown to directly or indirectly enhance nutrient uptake by grapevines (Nardi et al., 2016). The increased nutrient availability and improved physiological responses contribute to higher yields (Shahrajabian et al., 2021; Irani et al., 2021).

**Table 2: Effect of Budmaker on bunch and yield parameters of Nanasaheb Purple Seedless grapes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatments | No of bunches/ vine | No of berries/bunch | Average bunch weight (g) | 50 berry weight (g) | Yield/vinekg) |
| Pune location |
| T1- Control | 30.00 | 78.00 | 470.10 | 301.39 | 14.13 |
| T2- Budmaker @ 400 ml/L | 28.00 | 75.00 | 500.20 | 333.52 | 14.04 |
| T3- Budmaker @ 500 ml/L | 30.74 | 77.00 | 550.20 | 357.34 | 16.90 |
| T4- Budmaker @ 750 ml/L | 29.00 | 78.00 | 530.60 | 341.22 | 15.39 |
| CD at 5% | 2.24 | 4.21 | 13.91 | 15.51 | 1.11 |
| Sig | NS | NS | \*\* | \*\* | \*\* |
| Walwa location |
| T1- Control | 28.00 | 75.00 | 550.00 | 366.71 | 15.00 |
| T2- Budmaker @ 400 ml/L | 25.00 | 74.00 | 600.00 | 405.47 | 15.04 |
| T3- Budmaker @ 500 ml/L | 32.00 | 74.00 | 650.00 | 439.28 | 20.89 |
| T4- Budmaker @ 750 ml/L | 31.00 | 75.00 | 630.00 | 420.05 | 19.55 |
| CD at 5% | 5.85 | 1.72 | 16.40 | 0.40 | 3.81 |
| Sig | NS | NS | \*\* | \*\* | \*\* |

**Berry quality parameters**

 Berry length and berry diameter varied significantly among the different treatments. The treatment T4 recorded highest berry length (24.80 mm) followed by T2 (24.60 mm) and T3 (24.00 mm) as compared to the untreated control T1 (23.10 mm). The maximum berry diameter was recorded in T3 (20.60 mm) followed by T4 (20.50 mm) while minimum berry diameter was recorded in T2 (19.40 mm). The application of Budmaker had significant impact on berry diameter (Table 3). Budmaker showed non-significant variation for TSS of the grape berries. The acidity ranged from 0.36 % in T2 to 0.41 % in T3 treatment at Pune. A generally consistent trend, with some variation in values, was recorded at Walwa, Sangli district, Maharashtra. However, The TSS and acidity in grape berries was within the acceptable limit in all the treatments required for the export. Bio stimulants such as protein hydrolysates and humic substances significantly increase berry size, with studies indicating that treated berries exhibit greater length and diameter compared to controls (Nardi et al., 2016; Shahrajabian et al., 2021).

 **Table 3: Effect of Budmaker on berry quality parameters of Nanasaheb Purple Seedless grapes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** |  **Berry length (mm)** |  **Berry diameter (mm)** | **TSS (°Brix)** | **Acidity (%)** |
| **Pune location** |
| **T1- Control** | 23.10 | 19.50 | 18.00 | 0.38 |
| **T2- Budmaker @ 400 ml/L** | 24.60 | 19.40 | 18.20 | 0.36 |
| **T3- Budmaker @ 500 ml/L** | 24.00 | 20.60 | 19.00 | 0.41 |
| **T4- Budmaker @ 750 ml/L** | 24.80 | 20.50 | 18.80 | 0.39 |
| **CD at 5%** | **0.52** | **0.49** | **2.58** | **0.009** |
| **Sig.** | **\*\*** | **\*\*** | **NS** | **\*\*** |
| **Walwa location** |
| **T1- Control** | 23.40 | 20.10 | 17.50 | 0.55 |
| **T2- Budmaker @ 400 ml/L** | 24.50 | 21.50 | 17.80 | 0.52 |
| **T3- Budmaker @ 500 ml/L** | 24.10 | 22.80 | 18.00 | 0.55 |
| **T4- Budmaker @ 750 ml/L** | 23.60 | 21.20 | 17.90 | 0.54 |
| **CD at 5%** | **0.58** | **0.57** | **0.43** | **0.013** |
| **Sig.** | **\*\*** | **\*\*** | **NS** | **\*\*** |

**Chlorophyll content in leaf**

 The data recorded on chlorophyll content in leaf at 90 days after foundation pruning and fruit pruning of grapes is presented in Table 4. Chlorophyll b content in grape leaf during foundation pruning as well as during forward pruning was non-significant while total chlorophyll content after 90 days of fruit pruning was non-significant at Pune. However, treatments T3 showed highest chlorophyll a (12.35 ug/ml) and total chlorophyll content (16.11 ug/ml) while T1 had least chlorophyll a and total chlorophyll content (9.43 and 12.97 ug/ml). While, significant difference was recorded during foundation and fruit pruning at Walwa location of Sangli. Where, after 90 days of foundation pruning, the treatment T3 recorded higher chlorophyll a content in leaf (13.18 ug/ml) followed by T4 (12.95 ug/ml) while the control treatment recorded the least concentration of chlorophyll a in leaf (10.53 ug/ml). The same trend was also recorded for chlorophyll b content in leaf. Total chlorophyll content in leaf was higher in T3 (17.37 ug/ml) followed by T4 (16.93 ug/ml) and T2 (15.71 ug/ml) compared to the lowest in T1 control (14.51 ug/ml). After 90 days of fruit pruning, T2 recorded higher chlorophyll a content in leaf (13.78 ug/ml) followed by T4 (13.62 ug/ml) compared to the lowest concentration of 12.64 ug/ml in T1. Total chlorophyll content in leaf was higher in T4 (17.43 ug/ml) followed by T2 (17.39 ug/ml) compared to minimum in T1 control (16.48 ug/ml). The higher chlorophyll content in leaf during both the pruning time indicated the capacity of grapevine to store more food material required for the bunch development. The increase in chlorophyll content observed in Budmaker-treated plants may be attributed to enhanced nutrient uptake and improved physiological conditions. These factors contribute to better leaf health and greater photosynthetic efficiency, which in turn promote the transfer of sugars and starch and activate enzymes involved in chlorophyll synthesis, resulting in overall higher chlorophyll level in treated plants (Battacharyya, *et al*. 2015; Sharma et al., 2023)

**Table 4. Effect of Budmaker on chlorophyll content in leaf of Nanasaheb Purple Seedless grapes**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **90 Days Foundation 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** |
| **T1- Control** | 9.43 | 3.54 | 12.97 | 12.18 | 3.63 | 15.82 |
| **T2- Budmaker @ 400 ml/L** | 10.21 | 4.05 | 14.27 | 13.53 | 3.26 | 16.79 |
| **T3- Budmaker @ 500 ml/L** | 12.35 | 3.75 | 16.11 | 12.23 | 3.75 | 15.98 |
| **T4- Budmaker @ 750 ml/L** | 11.79 | 3.77 | 15.56 | 13.24 | 3.43 | 16.67 |
| **CD @ 5%** | 1.69 | 0.74 | 1.43 | 0.62 | 0.70 | 1.17 |
| **Sig** | \*\* | **NS** | **\*\*** | **\*\*** | **NS** | **NS** |
| **Walwa location** |
| **T1- Control** | 10.53 | 3.98 | 14.51 | 12.64 | 3.84 | 16.48 |
| **T2- Budmaker @ 400 ml/L** | 11.35 | 4.36 | 15.71 | 13.78 | 3.61 | 17.39 |
| **T3- Budmaker @ 500 ml/L** | 13.18 | 4.19 | 17.37 | 12.95 | 3.95 | 16.90 |
| **T4- Budmaker @ 750 ml/L** | 12.95 | 3.98 | 16.93 | 13.62 | 3.81 | 17.43 |
| **CD @ 5%** | 0.34 | 0.10 | 0.44 | 0.30 | 0.10 | 0.40 |
| **Sig** | \*\* | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** |

**Biochemical contents in grape berries**

 The data recorded on various biochemical contents is presented in Table 5. Phenol was relatively higher in T3 (0.56 mg/g) while it was lowest in T1 (0.37 mg/g) treatment. The treatment T3 recorded highest protein and reducing sugar (22.95 mg/g and 249.87 mg/g respectively), whereas T1 showed lowest protein (19.07 mg/g) while T2 recorded lowest reducing sugar (176.23 mg/g). The maximum calcium content in grape berries was recorded in treatment T3 (32.15 ppm) followed by T2 (31.85 ppm) while minimum calcium content was observed in treatment T1 (22.77 ppm). The maximum phosphorous content in leaf petiole at full bloom and veraison was recorded in T3 (0.552 % and 0.241% respectively) followed by T4 (0.489% and 0.237% respectively) whereas minimum phosphorous content at full bloom and veraison was recorded in T1 (0.416 and 0.220 %) at Pune location. Phosphorus content in leaf petiole was positively correlated with fruitful canes percent (0.920). Though the overall trend was similar, the recorded values at Walwa in Sangli district, Maharashtra, were distinct. Bio stimulants, particularly seaweed extracts, have shown remarkable potential in enhancing the accumulation of total phenolic compounds in grapevines, which is vital for improving both fruit quality and antioxidant properties (Irani et al., 2021). Their use stimulates key enzymes involved in phenolic metabolism, leading to a notable increase in the phenolic content of grape berries (Nardi et al., 2016). Additionally, biostimulants are crucial for optimizing nitrogen metabolism, a fundamental process for protein synthesis in grapevines. Enhanced nitrogen availability, especially during the bloom phase, has been associated with increased protein levels in plant tissues (Shahrajabian et al., 2021). Among the various types of biostimulants, protein hydrolysates stand out for their effectiveness in providing amino acids directly, thereby supporting protein synthesis in grapevines (Nardi et al., 2016). Bio stimulants have also been found to significantly boost sugar accumulation in grapevines, particularly under stress conditions. Seaweed extracts have been shown to increase total soluble solids (TSS), including reducing sugars, in grapevines under drought stress (Irani et al., 2021). Furthermore, the relationship between nitrogen availability and light during veraison plays a critical role in sugar accumulation. Biostimulants help regulate these factors, leading to improved sugar levels during this key developmental stage (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). Those containing seaweed extracts and humic substances are particularly effective, as they promote the development of root hairs, enhancing the absorption of essential nutrients like calcium and phosphorus (Nardi et al., 2016; Irani et al., 2021).

**Table 5: Effect of Budmaker on biochemical parameters of Nanasaheb Purple Seedless grapes**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Phenol mg/g** | **Protein mg/g** | **Reducing sugar mg/g** | **Calcium (ppm)** | **Phosphorus (%) full bloom** | **Phosphorus (%)****at veraison**  |
| **Pune location** |
| **T1- Control** | 0.37 | 19.07 | 222.88 | 22.77 | 0.416 | 0.220 |
| **T2- Budmaker @ 400 ml/L** | 0.50 | 21.80 | 176.23 | 31.85 | 0.504 | 0.223 |
| **T3- Budmaker @ 500 ml/L** | 0.56 | 22.95 | 249.87 | 32.15 | 0.552 | 0.241 |
| **T4- Budmaker @ 750 ml/L** | 0.44 | 21.29 | 242.17 | 29.92 | 0.489 | 0.237 |
| **CD at 5%** | **0.04** | **2.45** | **10.97** | **1.82** | **0.03** | **0.015** |
| **Sig** | **\*\*** | **\*** | **\*\*** | **\*\*** | **\*\*** | **\*** |
| **Walwa location** |
| **T1- Control** | 0.39 | 18.25 | 230.20 | 23.81 | 0.423 | 0.225 |
| **T2- Budmaker @ 400 ml/L** | 0.51 | 23.65 | 180.60 | 34.12 | 0.515 | 0.229 |
| **T3- Budmaker @ 500 ml/L** | 0.58 | 24.15 | 252.36 | 32.45 | 0.564 | 0.243 |
| **T4- Budmaker @ 750 ml/L** | 0.47 | 23.24 | 245.80 | 34.59 | 0.510 | 0.246 |
| **CD at 5%** | **0.016** | **0.64** | **6.46** | **0.86** | **0.015** | **0.007** |
| **Sig** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** | **\*\*** |

**Shelf-life**

              The data on shelf-life of grapes in terms of PLW (%) during storage at room temperature is presented in Fig. 1. In all the treatments, the PLW (%) increased with the advancement in storage duration. The minimum physiological loss in weight (%) was recorded in treatment T3 from 1st day (1.12 %), 2nd day (2.95 %), 3rd day (3.26 %), 4th day (3.49 %) and 5th day (5.17 %). The physiological loss in weight (%) in grape berries of control treatment increased rapidly from 1st day (1.85 %), 2nd day (3.57 %), 3rd day (4.12 %), 4th day (4.83 %) and 5th day (6.33 %) at ICAR-NRCG. A more or less comparable trend, but with different values, was observed in Walwa, Sangli district, Maharashtra. The data recorded on pedicel thickness and skin thickness of fresh berries is presented in Fig. 2. Pedicel thickness was relatively higher in T3 (0.660 mm) while it was lowest in T1 (0.510 mm) treatment at Pune location. A roughly comparable trend, though the values varied, was recorded in Walwa, Sangli district, Maharashtra. The increased thickness of the pedicel and skin plays a key role in enhancing the storability of grape bunch. Deshmukh et al. (2023) similarly observed that vines treated with biostimulants developed thicker skins, resulting in longer storage life compared to untreated grapes. The use of biostimulants may trigger lipid peroxidation processes and activate defense-related enzymes, which help maintain the firmness of grape berries. This, in turn, reduces fruit drop, minimizes physiological weight loss and prevents berry decay during storage (Liu et al., 2016; Zaharah et al., 2012; Deshmukh et al., 2023; Sharma et al., 2023).

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| Fig. 1. **Effect of Budmaker on physiological loss in weight (%) of Nanasaheb Purple Seedless grapes** |

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|  |
| Fig.2. **Effect of Budmaker on pedicel thickness (mm) and skin thickness (mm) of Nanasaheb Purple Seedless grapes** |

**Conclusion**

 A multi-location trial on Nanasaheb Purple Seedless grapes was conducted in 2023-24 to evaluate the bio-efficacy of Budmaker. Different doses of Budmaker were applied through foliar sprays and compared with an untreated control. All the treatments significantly enhanced fruit bud differentiation, early cane maturity, grape yield, berry quality and shelf life compared to the control. Among the treatments, T3 (500 ml/L Budmaker applied after the emergence of the sub-cane at the 1st, 3rd and 4th, 6th, and 7th leaves) showed the best performance. It notably improved fruitfulness, bunch and berry quality, shelf life and significantly increased yield. Based on the results, applying Budmaker at this concentration and timing is recommended to optimize Nanasaheb Purple Seedless grapevine yield and quality.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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