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ENHANCING PHOSPHORUS USE EFFICIENCY THROUGH BASIN DRENCHING OF PHOSPHORUS SOLUBILIZING BACTERIA: A SUSTAINABLE APPROACH FOR YIELD IMPROVEMENT AND FERTILIZER SAVING" IN GRAPE (*VITIS VINIFERA* L.) CV. THOMPSON SEEDLESS GRAFTED ON DOGRIDGE ROOTSTOCK

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ABSTRACT

The present investigation was carried out during 2023-24 and 2024-25 at the Grape Research Station, Rajendranagar, Sri Konda Laxman Telangana Horticultural University to study the effect of Phosphorus Solubilising Bacteria (PSB) basin drenching in combination with reduced phosphorus fertilizer levels on yield, quality and soil nutrient status of grape cv. Thompson Seedless grafted on Dogridge rootstock. The experiment was laid out in Randomized Block Design with seven treatments comprising different combinations of recommended dose of phosphorus (RDP) and PSB solution drenching at 1.0 and 2.0 ml per vine. The pooled results of two years revealed that yield parameters were significantly influenced by treatments, particularly number of bunches per vine and yield per vine. Among the treatments, T3 (75% RDP + PSB @ 2.0 ml/vine) recorded the highest yield (9.96 kg/vine), which was statistically on par with the control treatment T1 (100% RDP) with 9.84 kg/vine, indicating a saving of 25% phosphorus fertilizer without yield reduction. The number of bunches per vine was also highest in T1 (67.8) followed by T3 (66.3), showing that PSB enhanced reproductive performance under reduced fertilizer application. Quality parameters such as TSS and titrable acidity did not differ significantly among treatments, confirming that PSB drenching maintained fruit quality even under lower phosphorus levels. Soil available phosphorus differed significantly, with maximum values recorded in T1 (41.30 kg/ha) and T3 (40.12 kg/ha), suggesting improved phosphorus solubilization and availability due to PSB activity. Available nitrogen and potassium were not significantly affected. The findings confirm that basin drenching of PSB solution is an effective and eco-friendly strategy to improve phosphorus availability and nutrient use efficiency in grapes. Hence, application of PSB @ 2.0 ml/vine along with 75% RDP is recommended for sustainable grape production with reduced fertilizer input.

Keywords **:** Phosphorus Solubilising Bacteria (PSB), Grape (*Vitis vinifera* L.).

Introduction

Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crops cultivated extensively under tropical and subtropical regions of India. Among the cultivated varieties, Thompson Seedless is widely preferred due to its high productivity, suitability for raisin production, good market acceptability, and export potential. However, sustainable production of Thompson Seedless grapes largely depends on proper nutrient management, particularly phosphorus (P), which plays a critical role in root development, flowering, berry setting, carbohydrate metabolism, and overall vine vigour.

Phosphorus is an essential macronutrient required for grapevines, but its availability in soil is often limited because a major portion of applied phosphorus gets fixed in insoluble forms such as calcium phosphate in alkaline soils and iron/aluminium phosphates in acidic soils. As a result, even after applying recommended doses of phosphorus fertilizers,

the nutrient use efficiency remains low as reported by Halvin *et al*. (2014). This creates a need for alternative approaches that improve phosphorus availability and reduce dependency on chemical fertilizers.

Microorganism which helps to solubilize insoluble phosphate are called as phosphate solubilizing microorganisms (PSMs). In this context, the application of Phosphorus Solubilising Bacteria (PSB) has gained importance as an eco-friendly and cost-effective technology. PSB are beneficial microorganisms capable of converting insoluble phosphorus compounds into plant-available forms by secreting organic acids, chelation and exchange reaction (Zahoor *et al*., 2017). These acids dissolve fixed phosphate and release it into the soil solution, thereby improving phosphorus uptake by plants. PSB also enhances root growth, microbial activity, nutrient mobilization, and overall soil fertility. There are many strains of bacteria (Pseudomonas, Bacillus, Rhizobium, Enterobactor etc.) and fungi (Aspergillus and Penicillium) found to be as important phosphate solubilizes (Whitelaw, 2000; Peela *et al*., 2013).

The vine basin drenching method involves applying PSB solution directly into the root zone around the vine trunk, ensuring rapid colonization of beneficial bacteria in the rhizosphere. This method is considered more efficient because it targets the active feeder root region and increases microbial population near roots which helps in phosphorus solubilization and improves nutrient availability throughout the season. In grafted vineyards such as Thompson Seedless on Dogridge rootstock, basin drenching becomes even more significant because Dogridge has a strong root system and high nutrient absorption potential. When PSB is drenched into the basin, it improves nutrient mobilization, particularly phosphorus, and supports better vine growth and yield attributes.

Materials and Methods

The experiment was conducted for two consecutive years 2023-24 and 2024-25 at the vineyard of Grape Research Station, Rajendranagar situated at latitude of 17° 32' and longitude of 78° 40' E, under sub-tropical climatic conditions with an altitude of 536 m above mean sea level. The soil of the experimental site was sandy clay loam in texture. The vines used in the study were grape cv. Thompson Seedless grafted on Dogridge rootstock, uniformly aged and trained under standard vineyard management practices.

The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. The treatments consisted of combinations Recommended Dose of Phosphorus and Phosphorus Solubilising Bacteria as detailed below:

T1: Control (100% Recommended dose of Phosphorus fertilizer (RDP);
T2: 75% RDP + PSB @1.0 ml/vine;
T3: 75% RDP + PSB @ 2.0 ml/vine;
T4: 50% RDP + PSB @1.0 ml/vine;
T5: 50% RDP + PSB @ 2.0 ml/vine;
T6: 0% RDP + PSB @ 1.0 ml/vine and
T7: 0% RDP + PSB @ 2.0 ml/vine

Number of bunches per vine, average bunch weight, and yield per vine were recorded at harvest. Fruit quality parameters such as total soluble solids (TSS) were measured using a hand refractometer, and titrable acidity was determined by standard titration method as per Ranganna (1986).

Soil samples were collected from the root zone of grapevines after harvest from each treatment plot. The samples were air-dried, ground, and passed through a 2 mm sieve prior to analysis. Available nitrogen (kg ha^{-1}) was determined by the alkaline permanganate method as per Walkley and Black (1934). Available phosphorus (kg ha^{-1}) was estimated by the Olsen's method and available potassium (kg ha^{-1}) by neutral normal ammonium acetate extraction with flame photometry as per Jackson (1973).

The data collected over two years were pooled and subjected to analysis of variance (ANOVA). Treatment means were compared using critical difference (CD) at 5% level of significance and standard error of mean (SEM) was calculated.

Table 1 : Effect of Phosphorus Solubilising Bacteria on yield and quality of grape cv. Thompson seedless grafted on Dogridge root stock (Pooled data of two years)

Treatments	No. of bunches/vine	Average Bunch weight (g)	Yield (kg/vine)	TSS (°B)	Acidity (%)
T1	67.8	145.2	9.84	23.0	0.41
T2	64.0	144.8	9.24	22.2	0.47
T3	66.3	149.8	9.96	23.0	0.42
T4	61.7	146.7	9.06	22.5	0.47
T5	56.7	142.3	8.05	22.0	0.49
T6	54.0	142.6	7.74	22.4	0.45

T7	57.3	139.4	7.97	22.2	0.45
SEm±	3.16	2.62	0.51	0.52	0.03
CD (5%)	9.73	NS	1.56	NS	NS

T1 – control (100% Recommended dose of Phosphorus fertilizer (RDP); T2- 75% RDP + PSB @1.0 ml/vine; T3- 75% RDP + PSB @ 2.0 ml/vine; T4- 50% RDP + PSB @1.0 ml/vine; T5- 50% RDP + PSB @2.0 ml/vine; T6- 0% RDP + PSB @1.0 ml/vine; T7- 0% RDP + PSB @2.0 ml/vine

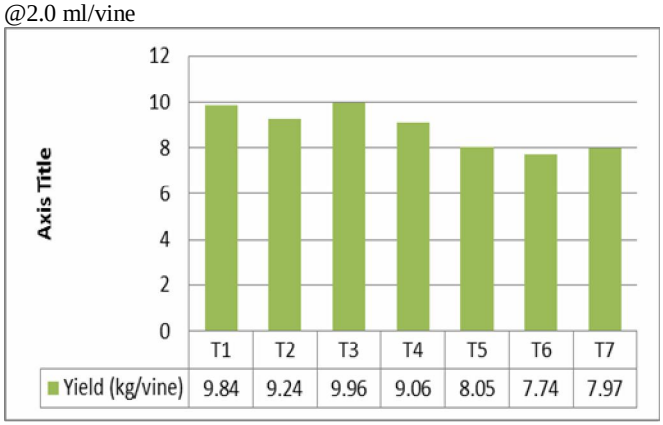

Fig. 1: Effect of PSB on Yield (kg/vine) in Grape

Table 2 : Effect of Phosphorus Solubilising Bacteria on soil available nitrogen, phosphorus and potassium of grape cv. Thompson seedless grafted on Dogridge root stock

Treatments	Available Nitrogen (Kg/ha)	Available phosphorus (Kg/ha)	Available potassium (Kg/ha)
T1	317	41.30	266.23
T2	304	33.99	272.43
T3	320	40.12	258.13
T4	312	37.83	266.83
T5	308	31.55	281.43
T6	299	30.30	285.43
T7	315	32.65	254.43
SEm±	10.0	2.51	10.2
CD (0.05)	NS	7.72	NS

T1 – control (100% Recommended dose of Phosphorus fertilizer (RDP); T2- 75% RDP + PSB @1.0 ml/vine; T3- 75% RDP + PSB @ 2.0 ml/vine; T4- 50% RDP + PSB @1.0 ml/vine; T5- 50% RDP + PSB @2.0 ml/vine; T6- 0% RDP + PSB @1.0 ml/vine; T7- 0% RDP + PSB @2.0 ml/vine

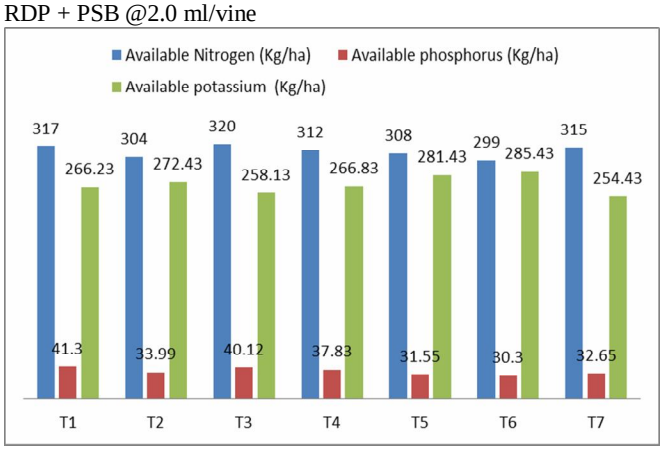

Fig. 2 : Effect of PSB on soil available NPK in Grape

Results and Discussion

Yield and Quality Parameters

The pooled data of two years clearly indicates that PSB drenching along with reduced phosphorus fertilizer levels influenced vine productivity significantly.

Effect on Yield Parameters

Among the treatments, T3 (75% RDP + PSB @ 2.0 ml/vine) recorded the highest yield (9.96 kg/vine**)** which was statistically on par with T1 (100% RDP control) showing 9.84 kg/vine. This indicates that 25% of chemical phosphorus fertilizer could be saved by integrating PSB drenching without affecting yield. Khan etal. (2007) reported that PSB improves phosphorus availability and yield with reduced fertilizer doses. The increase in yield under PSB treatments may be attributed to the ability of PSB to solubilize insoluble phosphates through secretion of organic acids such as gluconic acid and citric acid, thereby improving phosphorus availability as reported by Rodriguez and Fraga (1999). Improved phosphorus availability might have promoted better root development, energy transfer (ATP formation), and metabolic activity, ultimately resulting in improved bunch formation and yield.

The number of bunches per vine showed significant difference. The maximum bunch number was recorded in T1 (67.8) followed by T3 (66.3) and T2 (64.0). This clearly shows that PSB application @ 2.0 ml/vine supported better fruiting potential even under reduced fertilizer levels. Increased bunch number under PSB treatments could be due to enhanced nutrient availability leading to better bud differentiation and improved fruitfulness.

The average bunch weight did not show significant variation, suggesting that the improvement in yield was mainly due to increased bunch number rather than bunch size.

Thus, basin drenching of PSB played a major role in sustaining yield by improving nutrient availability and encouraging reproductive growth.

Effect on Quality Parameters

Quality attributes like TSS and acidity were not significantly influenced by treatments, indicating that reduction of phosphorus fertilizer up to 75% with PSB

did not deteriorate berry quality. Phosphorus is essential for sugar transport and energy metabolism. Hence, PSB-induced phosphorus availability might have supported optimum sugar accumulation without altering fruit biochemical composition.

Effect on Soil Available Nutrients:

Soil available phosphorus differed significantly. The highest available phosphorus was recorded in T1 (41.30 kg/ha) followed by T3 (40.12 kg/ha)**.** This proves that PSB application at 2.0 ml/vine with 75% RDP effectively improved soil phosphorus availability almost equal to the full recommended dose. The increase in available phosphorus may be due to microbial release of organic acids, chelation of calcium ions, and enzymatic activity (phosphatases), which convert unavailable phosphorus into plant-available forms. Illmer and Schinner (1995); Gyaneshwar *et al*. (2002); Sharma *et al*. (2013) also reported the role of PSB in phosphorus solubilisation. Available nitrogen and potassium were not significantly affected.

The results confirm that basin drenching of PSB solution is a promising practice in grape production as it enhances phosphorus solubilization in soil, improves phosphorus availability and maintains yield and fruit quality even with reduced fertilizer dose

Conclusion

From the pooled results of two years, it can be concluded that T3 (75% RDP + PSB @ 2.0 ml/vine) is the most effective treatment, producing the highest yield and maintaining fruit quality comparable to control (100% RDP). Additionally, it recorded higher soil available phosphorus, indicating improved nutrient status in the vineyard. Therefore, drenching of PSB solution in vine basin is an efficient biofertilizer approach, enabling sustainable grape cultivation by reducing dependence on chemical phosphorus fertilizers while sustaining productivity and soil health.

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