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FOLIAR APPLICATION OF SUB-SOIL SOLUTION AS A SUPPLEMENTARY NUTRIENT SOURCE: IMPACT ON YIELD, QUALITY AND NUTRIENT DYNAMICS OF GRAPE (*VITIS VINIFERA* L.) CV. THOMPSON SEEDLESS GRAFTED ON DOGRIDGE ROOTSTOCK

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ABSTRACT

A field experiment was conducted for two consecutive years 2023-24 and 2024-25 to evaluate the effect of foliar spray of sub-soil solution on yield, quality, soil fertility, and petiole nutrient status of grape (*Vitis vinifera* L.) cv. Thompson Seedless grafted on Dogridge rootstock. The experiment comprised five treatments involving FYM, recommended dose of fertilizers (RDF), and foliar application of sub-soil solution at weekly and fortnightly intervals. The pooled analysis of two years revealed that FYM + RDF + weekly foliar spray of sub-soil solution (T3) recorded the highest number of bunches per vine (66.79) and yield (9.21 kg vine^{-1}), which were significantly superior to FYM-based treatments without RDF. With regard to fruit quality parameters, T2 (FYM + fortnightly foliar spray of sub-soil solution) recorded the highest TSS (22.7 ° Brix) and it was on par with T3 (22.6 ° Brix). Soil organic carbon, available nitrogen, phosphorus, and micronutrients showed non-significant variation, whereas available potassium differed significantly among treatments, with higher values under RDF-based treatments. Petiole N, P, and K content at bloom stage did not differ significantly, though higher nutrient concentrations were observed under T3. The sub-soil solution possessed neutral pH, low EC, and appreciable quantities of macro- and micronutrients, making it suitable for foliar application. The study concludes that weekly foliar spray of sub-soil solution in conjunction with FYM and RDF enhances yield of Thompson Seedless grape without adversely affecting fruit quality or soil health.

***Key words*:** Grapevine (*Vitis vinifera* L.), Yield, Quality, Soil Fertility

Introduction

Grapevine (*Vitis vinifera* L.) is one of the most important fruit crops cultivated in tropical and subtropical regions of India, contributing significantly to fruit production and farmer income. Among the cultivated varieties, Thompson Seedless is widely grown due to its high yield potential, superior fruit quality, and suitability for raisin and table purposes. However, intensive cultivation of grapes demands balanced and timely nutrient management to sustain productivity and soil health.

Conventional nutrient management practices relying solely on chemical fertilizers often lead to nutrient imbalances, declining soil fertility, and reduced nutrient use efficiency. Integrated nutrient management (INM) involving organic manures, inorganic fertilizers, and supplementary nutrient sources, has been advocated to improve vine nutrition and long-term soil sustainability (Singh *et al.*, 2012; Sharma *et al.*, 2018).

Foliar nutrition is an effective method of supplying nutrients directly to plants during critical phenological stages, especially under conditions where soil nutrient availability is restricted. Recently, the use of sub-soil solution as a foliar nutrient source has gained attention due to its content of soluble macro- and micronutrients, low salinity, and cost-effectiveness. Sub-soil layers, though poor in organic carbon, often contain appreciable quantities of minerals that can be utilized through foliar application without disturbing soil nutrient pools.

Therefore, the present investigation was undertaken to study the effect of foliar spray of sub-soil solution, in combination with FYM and RDF, on yield, quality, soil nutrient status and petiole nutrient composition of grape cv. Thompson Seedless grafted on Dogridge rootstock.

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^{o} 32' and longitude of 78^{o} 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 five treatments and four replications. The treatments consisted of combinations of FYM, RDF, and foliar application of sub-soil solution as detailed below:

T1: FYM + weekly foliar spray of sub-soil solution

T2: FYM + fortnightly foliar spray of sub-soil solution

T3: FYM + RDF + weekly foliar spray of sub-soil solution

T4: FYM + RDF + fortnightly foliar spray of sub-soil solution

T5: FYM + RDF (control)

Farmyard manure and recommended dose of fertilizers were applied as per standard package of practices for grape cultivation.

Sub-soil samples were collected from 4 ft depth and were analyzed for chemical properties. The sub-soil was soaked with water in 1:5 ratio, stirred well and kept overnight and the supernatant solution was used for foliar spray at prescribed intervals. Mengel and Kirkby (2001) reported that foliar application of nutrients is an efficient means of correcting temporary nutrient deficiencies and supplementing soil fertilization due to the reason that, foliar-applied nutrients are rapidly absorbed through leaf cuticles and stomata and directly enter metabolic pathways, resulting in improved photosynthesis, assimilate production and reproductive development.

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).

Table 1: Effect of foliar spray of sub soil solution on yield and quality of grape cv. Thompson seedless grafted on Dogridge root stock (Pooled data of two years).

Treatments	NBV	ABW	YL	TSS	AD
T1	49.58	127.9	6.34	22.0	0.46
T2	44.00	129.4	5.71	22.7	0.44
T3	66.79	137.7	9.21	22.6	0.42
T4	60.88	133.9	8.15	21.5	0.44
T5	64.00	123.9	7.85	21.0	0.43
SEm±	1.83	3.25	0.26	0.34	0.02
CD (5%)	5.63	NS	0.79	1.04	NS

NBV: No. of bunches/vine; ABW: Average Bunch weight (g)
YL: Yield (kg/vine); TSS: TSS (^{o}B); AD: Acidity (%)
T1 – FYM + weekly foliar spray of sub soil solution;
T2- FYM + fortnightly foliar spray of sub soil solution;
T3- FYM + RDF + weekly foliar spray of sub soil solution;
T4- FYM + RDF + fortnightly foliar spray of sub
soil solution; T5- FYM + RDF (control)

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. Organic carbon (%) was estimated by the Walkley and Black wet oxidation method. 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). Available soil micronutrients viz., zinc (Zn), iron (Fe), and copper (Cu) were extracted using DTPA solution and quantified using an Atomic Absorption Spectrophotometer (AAS) as per Lindsay and Norvell (1978).

Petiole samples were collected at the bloom stage from fully expanded leaves opposite the flower clusters. Seivastava and Singh (2009) reported that petiole nitrogen, phosphorus, and potassium concentrations at bloom are strongly associated with vine vigour, flowering intensity, and subsequent yield formation. This supports the methodology adopted in the present investigation, where petiole N, P, and K were analyzed at bloom stage to evaluate treatment effects. Nitrogen (%) content in petioles was estimated by the Kjeldahl method, phosphorus (%) by the vanadomolybdate yellow colour method using a spectrophotometer, and potassium (%) by flame photometry as per Piper (1966)

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 2: Effect of foliar spray of sub soil solution on soil organic carbon as well as available nitrogen, phosphorus and potassium of grape cv. Thompson seedless grafted on Dogridge root stock.

Treatments	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
T1	0.39	301.4	33.8	280.1
T2	0.40	303.9	32.3	272.6
T3	0.44	314.2	37	305.0
T4	0.42	322.4	38	303.7
T5	0.42	310.8	36.4	306.5
SEM	0.02	8.1	1.7	7.9
CD (0.05)	NS	NS	NS	24.4

T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)

Results and Discussion

Yield and Quality Parameters

The pooled data of two years clearly indicated that foliar application of sub-soil solution significantly influenced yield attributes of grape cv. Thompson Seedless grafted on Dogridge rootstock, while quality parameters were largely unaffected (Table 1).

Among the treatments, T3 (FYM + RDF + weekly foliar spray of sub-soil solution) recorded highest number of bunches per vine (66.79), which was significantly superior to T1 and T2. The increased bunch number under T3 may be attributed to better vine vigour and improved nutrient availability resulting from the combined application of FYM, recommended fertilizers and frequent foliar supplementation of nutrients through foliar spray of sub-soil solution.

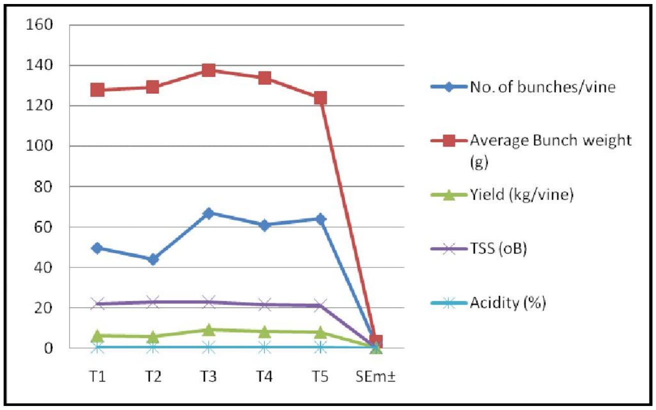

Fig. 1: Graphical representation of the effect of foliar spray of sub soil solution on yield and quality of grape cv. Thompson seedless grafted on Dogridge root stock. [T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)].

Table 3: Effect of foliar spray of sub soil solution on soil available micronutrients of grape cv. Thompson seedless grafted on Dogridge root stock.

Treatments	Zinc (mg/kg)	Iron (mg/kg)	Copper (mg/kg)
T1	0.41	1.66	0.21
T2	0.38	1.47	0.20
T3	0.34	1.29	0.17
T4	0.32	1.20	0.17
T5	0.33	1.15	0.16
SEM	0.03	0.1	0.01
CD (0.05)	NS	NS	NS

T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)

Average bunch weight did not differ significantly among treatments; though numerically higher values were observed in T3 (137.7 g). Consequently, yield per vine was maximum in T3 (9.21 kg/vine), which was significantly higher than T1 and T2 and closely followed by T4. The superiority of T3 reveals that the difference in yield is mainly due to application of recommended fertilizers along with weekly foliar spray of sub-soil solution which might have enhanced assimilates production and partitioning towards reproductive sinks. Sharma *et al.*, 2005 also reported increased no. of

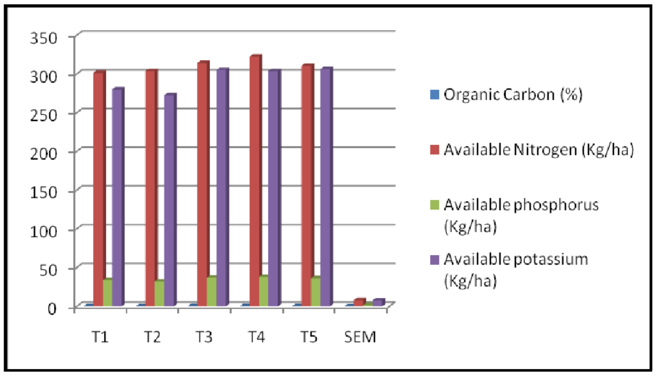

Fig. 2: Graphical representation of the effect of foliar spray of sub soil solution on soil organic carbon as well as available nitrogen, phosphorus and potassium of grape cv. Thompson seedless grafted on Dogridge root stock. [T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)].

Table 4: Effect of foliar spray of sub soil solution on petiole N, P,K status at bloom stage of grape cv. Thompson seedless grafted on Dogridge root stock.

Treatments	N (%)	P (%)	K (%)
T1	1.26	0.23	0.98
T2	1.28	0.21	0.97
T3	1.40	0.25	1.04
T4	1.31	0.23	0.98
T5	1.26	0.24	1.03
SEM	0.04	0.01	0.02
CD (0.05)	NS	NS	NS

T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)

bunches and yield with foliar nutrient sprays

Total Soluble Solids (TSS) of grape berries differed significantly among the treatments. TSS values ranged from 21.0 to 22.7 °Brix with the critical difference (CD at 5%) of 1.04 °Brix, suggesting that treatment effects were statistically discernible.

Among the treatments, T2 (FYM + fortnightly foliar spray of sub-soil solution) recorded the highest mean TSS (22.7 °Brix), which was on par with T3 (22.6 °Brix). The enhanced TSS under T2 and T3 may be attributed to improved nutrient availability and physiological efficiency due to foliar application of sub-soil solution, which likely promoted better carbohydrate synthesis and translocation to the berries. Keller, 2010 reviewed that adequate nutrient status particularly Nitrogen is important for leaf photosynthetic activity and thus carbohydrate availability and potassium involves in efficient sugar transport from leaves to berries driving the rise in TSS.

Soil Organic Carbon and Available Macronutrients and Micronutrients

Foliar application of sub-soil solution had non-significant effect on soil organic carbon and available nitrogen and phosphorus, whereas available potassium showed significant variation (Table 2).

Available nitrogen and phosphorus were higher in RDF-based treatments, with T4 recording the highest available nitrogen (322.4 kg/ha) and T4 and T3 recording higher available phosphorus (38 and 37 kg/ha, respectively). However, these differences were statistically non-significant.

Available potassium differed significantly, with T5 (306.5 kg/ha), T3 (305.0 kg/ha), and T4 (303.7 kg/ha) recording higher values compared to T1 and T2. This indicates that soil K status was primarily governed by RDF application rather than foliar sprays of sub-soil solution.

Table 5: Chemical parameters of Soil.

Chemical parameters of soil	Available Content in sub soil (4 ft depth) used for foliar spray
pH	7.36
EC	0.25 dS/m
OC	0.21 %
Nitrogen	224 kg/ha
Phosphorus	20.83 kg/ha
Potassium	25.5 kg/ha
Cu	0.95 mg/kg
Fe	4.55 mg/kg
Zn	1.18 mg/kg

The results suggest that foliar spraying of sub-soil solution did not markedly alter bulk soil fertility, as the nutrients were applied through foliage and not directly to the soil.

Soil available zinc, iron, and copper did not show significant differences among treatments (Table 3).

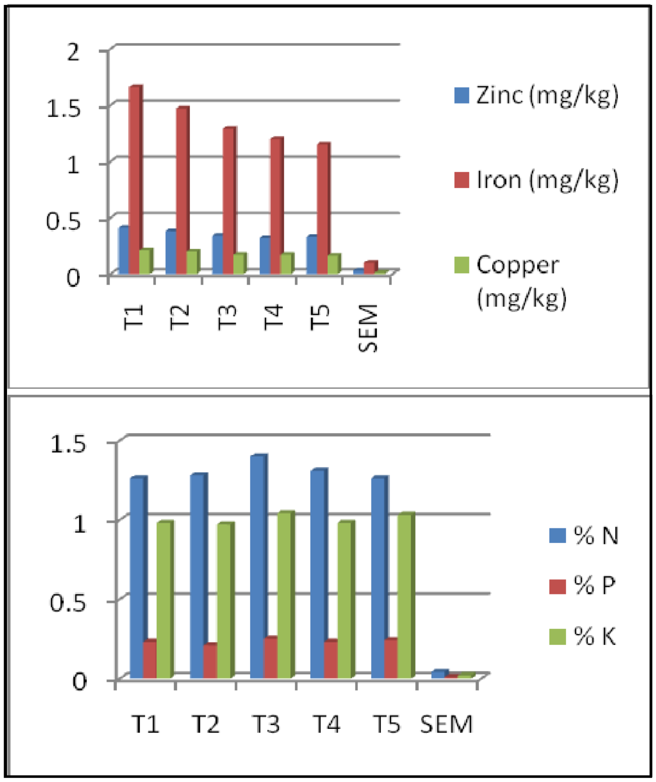

Fig. 3: Graphical representation of the effect of foliar spray of sub soil solution on soil available micronutrients as well as petiole N, P,K status at bloom stage of grape cv. Thompson seedless grafted on Dogridge root stock. [T1 – FYM + weekly foliar spray of sub soil solution; T2- FYM + fortnightly foliar spray of sub soil solution; T3- FYM + RDF + weekly foliar spray of sub soil solution; T4- FYM + RDF + fortnightly foliar spray of sub soil solution; T5- FYM + RDF (control)].

Petiole Nutrient Status at Bloom Stage

Petiole analysis at bloom stage revealed non-significant differences in N, P, and K concentrations among treatments (Table 4). Nevertheless, T3 recorded the highest petiole nitrogen (1.40%) and potassium (1.04%), while phosphorus content was also relatively higher (0.25%).

This indicates that integrated nutrient management involving FYM, RDF, and weekly foliar spray of sub-soil solution ensured better nutrient uptake and internal nutrient balance, which ultimately reflected in higher yield performance.

Composition of sub-soil solution used for foliar spray

The sub-soil solution collected from 4 ft depth and used for foliar application was slightly alkaline in reaction (pH 7.36) with low electrical conductivity (0.25 dS m^{-1}), indicating that the solution was non-saline and safe for repeated foliar application on grapevines without the risk of leaf scorch or salt injury.

The solution contained low organic carbon (0.21%), reflecting the inherently poor organic matter status of sub-soil layers. However, appreciable quantities of plant-available macronutrients were present. Available nitrogen was 224 kg ha^{-1}, while phosphorus and potassium contents were 20.83 kg ha^{-1} and 25.5 kg ha^{-1}, respectively. Although these values are lower than typical surface soil fertility levels, their presence in soluble form makes them potentially effective when supplied directly through foliage, especially during periods of high nutrient demand.

The sub-soil solution was also a source of essential micronutrients, particularly iron (4.55 mg kg^{-1}) and zinc (1.18 mg kg^{-1}), along with copper (0.95 mg kg^{-1}). These micronutrients play a crucial role in chlorophyll synthesis, enzymatic activity, and overall vine metabolism.

Overall, the balanced composition, neutral pH, and low salinity of the sub-soil solution made it suitable for foliar application. The presence of both macro- and micronutrients, even at moderate levels, suggests that the solution acted as a supplementary nutrient source, enhancing nutrient availability to the vines without significantly altering soil nutrient status.

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