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Foliar Macro and Micro-Nutrient Sprays Improved Yield and Quality of Flame Seedless Grapevine

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Abstract: Field examination spanning two years (2022-2023) have been done in the vine region of Minia Governorate, West of Samalout Center, to evaluated the effects of foliar application of different concentrations of macronutrients (NPK) and micronutrients (Zn, B, Fe), alone and in combination, on the yield and fruit quality of Flame Seedless grapevines. Treatments were applied thrice during the growing season, and results demonstrated that combined foliar sprays of macro and micronutrients significantly improved yield parameters such as berry set percentage, cluster number and weight, and overall yield per vine compared to untreated controls. The highest improvements in both yield and berry quality were achieved with the combined application of 1.0% NPK + 150 ppm Zn/B + 200 ppm Fe, followed closely by 0.75% NPK + 100 ppm Zn/B + 150 ppm Fe. These treatments also enhanced berry size, weight, chemical attributes including total soluble solids, TSS/TA, reducing sugars, and anthocyanin content and reduced shot berry percentage, as well as total acidity. The findings suggest that integrated foliar nutrient management optimizes both productivity and fruit quality in Flame Seedless grapevines under Minia field conditions.

Key words: Macro, micronutrient, yield, berry quality and Flame seedless.

1. Introduction

The grapevine (*Vitis vinifera* L.) is one of the most significant fruits produced globally, utilized for both fresh consumption and the production of raisins. It occupies more area globally than any other fruit crop and accounts for roughly half of all consumption worldwide. Grapes rank as the third most cultivated fruit in Egypt, following mangoes and citrus (**Mostafa *et al.*, 2023**). The grape cultivation region in Egypt encompasses 186735 feddans, with a productive area of 175245 feddans, resulting in an aggregate production of 1715410 ton. The cultivated land in Minia Governorate amounted to 21098 feddans, with a productive area of 20852 feddans, resulting in a total of 205244 ton (**MALR, 2023**).

Balancing productivity and fruit quality is a primary objective in viticulture, particularly challenging due to the impacts of climate change and weather variability (**James *et al.*, 2022**). The development of the grapevine and, consequently, the production of high-quality grapes can be significantly influenced by the application of modern agro-technical measures, with a particular emphasis on nutrition. This involves the administration of optimal doses and types of fertilizers during the appropriate period (**Stojanova, 2023**).

Effective management of vineyard nutritional requirements necessitates a visual evaluation of grapevines, their growth patterns, and the nutrient status of plant tissues and soil to formulate a suitable fertilization strategy. Vineyards exhibit distinct combinations of soil type, grapevine age, canopy architecture, and cultivars, leading to variability in nutritional requirements both among different vineyards and within specific locations of a single vineyard (**Arrobas *et al.* 2014**).

Nutrition should be correlated with the phenophases of plant development, as the grapevine, a perennial crop, requires substantial quantities of nutrients that are utilized differently during various phenophases. The unavailability of nutrients for plants frequently results in the administration of nutrients through the soil not yielding the anticipated results. Therefore, the effective cultivation of the grapevine and the production of high-quality grapes are contingent upon the intake of physiologically active substances through the leaf (**Stojanova *et al.*, 2024**). The hydrolytic processes in the reproductive organs are stimulated, the photosynthetic processes are accelerated, and an additional influx of nutrients and their migration into the growth and fruiting organs are created during foliar feeding, when the grapevine is supplied with sufficient amounts of macro and microelements in an active form at specific concentrations (**Stojanova, 2018**).

The roots of plants absorb nutrients that are found naturally in the soil. An excessive amount of nutrients causes the vine to grow quickly, creating a dense canopy that either overshadows the fruit or exhibits a wide range of toxicity. However, over time, soil nutrients are lost and must be restored using mineral fertilizers in order to increase grape output and quality. Chlorosis, which causes leaves to turn yellow instead of purple, is a typical symptom associated with a shortage of nutrients. This results in limited photosynthesis and makes it difficult for grapes to develop properly, lowering quality and yield. Using the right fertilizers, especially a blended formulation that offers both macro and micronutrients, can solve the issue (**Gur *et al.*, 2022**). NPK levels have the most instantaneous impact, which can increase the yield and quality of the berries (**Michopoulos and Solomou, 2019 and Fiaz *et al.*, 2021**).

Nitrogen, phosphorus, and potassium are the primary macronutrients that directly influence plant growth and the development of various plant structures. Nutrients such as nitrogen and potassium exhibit significant mobility, allowing for rapid translocation from older to younger leaves when the demand in the young leaves or fruiting bodies exceeds the supply from the soil. This can lead to chlorosis and necrosis (**Michopoulos and Solomou, 2019 and Jegadeeswari *et al.*, 2020**). Nevertheless, the situation is different for micronutrients, as they are typically applied directly to the vegetative portion through foliar sprays and are necessary in trace quantities. In general, these nutrients interact with one another to influence numerous pathways within the plant (**Kumar *et al.*, 2021**). An effective fertilizer management program is dependent on selecting the appropriate fertilizer to meet the specific shortage detected in the vineyard, the correct rate of nutrient demand, and the timing of fertilizer application (**Rahaman *et al.*, 2019**). Collectively, these benefits include soil and environmental conservation, as well as improved grape quality and production.

This systematic approach seeks to found the suitable concentration for macro and micro nutrients management on yield, fruit quality, and berries biochemical properties of Flame Seedless grapevines, addressing gaps in synergistic interactions between macro- and micronutrients under Minia Governorate field conditions.

2. Materials and Methods

2.1. Description of the experimental site

Field examination spanning two years (2022-2023) have been done in the vine region of Minia Governorate, West of Samalout Center, which possesses agro-ecologically advantageous circumstances for cultivating Flame Seedless grapevine. Clay soils are the soil type in the experimental site (Table A), as determined by **Wilde *et al.* (1985**). In both seasons, a cane pruning system was implemented during the second week of December, resulting in 80 eyes per vine (8 canes × 8 eyes per cane + 8 renewal spurs × 2 eyes) with a row spacing of 2 x 3 m.

With regular fertilization, the thirty vines that were selected were consistently robust and vigorous, exhibiting no visible signs of nutrient shortages. Water from the Nile Rivier was used to irrigate the vineyard using a surface irrigation system.

Table (A). Examined soil properties

Soil characters		**2022/2023**
Particle size distribution (%)	**Sand**	2.10
	Silt	34.85
	Clay	63.05
	Texture class	Clay
EC ppm (1:2.5 extract)		291
pH (1:2.5 extract)		7.82
Organic matter %		2.23
$CaCO_3$ %		2.51
Soil nutrients	**Total N (%)**	0.15
	Available P (ppm)	5.08
	Available K (ppm)	491.0
	Zn (ppm)	2.3
	Fe (ppm)	2.5
	Mn (ppm)	3.1
	Cu (ppm)	0.11

2.2. Treatments and design of the experimental

The experiment has been conducted according the method of complete randomized block design with one vine/treatment and three repetitions. The treatments were organized in the following manner:

1- T1 (control spray with tap water).

2- T2: Zn (50 ppm) + B (50 ppm) + Fe (100 ppm).

3- T3: Zn (75 ppm) + B (75 ppm) + Fe (150 ppm).

4- T4: Zn (100 ppm) + B (100 ppm) + Fe (200 ppm).

5- T5: N (0.5%) + P (0.5%) + K (0.5%).

6- T6: N (0.75%) + P (0.75%) + K (0.75%).

7- T7: N (1.0%) + P (1.0%) + K (1.0%).

8- T8: T2 + T5.

9- T9: T3 + T6.

10- T10: T4+ T7.

At three distinct intervals: at the onset of growth, immediately following berry set, and one month thereafter, each treatment was administered with the studied dosages of macronutrients, including nitrogen in the form of ammonia (46.0% N), P in the form of phosphoric (85.0%), and K in the form of potassium sulfate (50.0%), and micronutrients, including Fe in the form of ferrous sulfate (19.7%), Zn in the form of zinc sulfate (21.0%) and B in the form of borax (11.5%). The applying of macro and micro applications was separated by a week in early morning hours.

2.3. Data recorded

The subsequent parameters were analyzed to ascertain the effects of the aforementioned treatments:

2.3.1. Yield and physical attributes of clusters

Ten clusters per vine were chosen as typical random samples, and the following parameters were determined: Clusters number/vine, cluster weight (g), yield (kg)/vine was assessed in kg for each tree/replicate by multiply the previous parameters, cluster dimensions (length and shoulder in (cm)) and berry setting (%) was computed as the following: packed 5 flower clusters per vine in perforated paper bags before bloom, which are discharged during berry set which computed as follows:

$$\text{Fruit berry Setting\%} = \frac{\text{Number of berries /cluster}}{\text{Total number of flower /cluster}}$$

2.3.2. Physical characteristics of berries

To calculate the shot berry proportion, divide the percentage of berries in each cluster by the total number of berries across all clusters, then multiply by 100, berry weight (g) and berry dimensions (longitudinal and equatorial).

2.3.3. Chemical characteristics of berries according to (**A.O.A.C., 2000**)

TSS% in berry juice measured with a handheld refractometer, titrating 5 ml of berry juice against 0.1 N NaOH with phenolphthalein determined the titratable acidity percentage. TSS/acidity ratio of berry juice was calculated, reducing sugar% and the total anthocyanin content in berry skin was evaluated using a spectrophotometer, adhering to the methodology established by **Yilidz and Dikmen (1990).**

4. Data Analysis

The new LSD technique was employed to analyze the data at a significance level of 5%, as described by **Mead *et al.* (1993).**

3. Results and Discussion

3.1. Yield and physical attributes of clusters

The data presented in Table (1) indicate that the yield metrics encompass berry setting percentage, number of clusters per vine, average cluster weight (g), and measurements of cluster length and width (cm), alongside yield (kg/vine) were significantly influenced by different concentrations of macro and/or micro nutrient foliar applications. The application of both fertilizers to the vines three times led to a significant increase in yield traits relative to the control treatment. An incremental improvement of these characteristics was noted with increasing concentrations. The yield parameters remained relatively stable as concentrations increased from 0.75% to 1.0% for NPK and from 75 ppm to 150 ppm and 150 ppm to 200 ppm for Zn, B, and Fe. The vines treated with macronutrients exhibited the highest values at 1.0% (T7), followed by 0.75% (T6). When the treatments were combined, the percentage of berry setting in yield parameters of Flame seedless vines increased relative to the control and other treatments. During the two seasons, no significant differences were observed between the two highest concentrations. The highest mean values were observed with the combination of T10 (1.0% NPK + 150 ppm Zn/B + 200 ppm Fe), followed by T9 (0.75% NPK + 100 ppm Zn/B + 150 ppm Fe). The untreated plants exhibited the lowest mean values of traits. The findings were consistent across both seasons.

The enhancement of grapevine yield and its key components, including cluster number per vine, weight, yield in kg per vine, berry setting percentage, cluster length, and shoulder dimensions, has been demonstrated in numerous scientific studies by the application of both macronutrient (NPK) and micronutrient (Zn, B, Fe) fertilization.

Using NPK fertilizers has been demonstrated to greatly boost grape yields by promoting vegetative growth, nitrogen uptake, and reproductive development. Nitrogen is especially important for making proteins and chlorophyll, which helps shoots and leaves grow quickly. This process facilitates the development of leaves and branches, resulting in a greater number of fruitful shoots and clusters per vine (**Khalil *et al.*, 2018**). Potassium controls the balance of water and the activation of enzymes, both of which help fruit set and berry development. Phosphorus is important for transferring energy and growing roots (**Imam and Al-Obaidi, 2020**). Research has found that increasing NPK doses, can lead to higher cluster numbers, greater cluster weight, and increased overall yield. For example, a study by **Wassel *et al.* (2024b)** reported that vines receiving Min-NK and bio-P, produced the highest values for cluster weight, number/vine, yield per vine, and yield per hectare.

Micronutrients are equally important for optimizing grape yield and quality. Zinc is involved in enzyme activation and auxin synthesis, which influence flower development and fruit set. Boron is essential for pollen viability, fertilization, and cell wall formation, directly affecting berry set and cluster formation. Iron is critical for chlorophyll synthesis and energy transfer within the plant (**Brunetto *et al.*, 2015; Khalil *et al.*, 2018 and Abd Sattar *et al.*, 2024)**. Foliar application of these micronutrients, either alone or in combination, has been shown to significantly enhance berry set percentage, increase the number of clusters per vine, and improve cluster weight compared to untreated controls **(Abd Sattar *et al.*, 2024)**.

The combined application of NPK and micronutrients often produces a synergistic effect, resulting in greater increases in yield and its components than when either is applied alone (**Khalil *et al.*, 2018 & 2021**). Studies have shown that vines treated with both macronutrients and micronutrients not only exhibit higher berry set percentages but also achieve the greatest increases in cluster number and weight, reflecting improved fruit set and development throughout the growing season (**Khalil *et al.*, 2018 & 2021and Masoud *et al.*, 2025).**

Table (1). Impact of applying some macro and micro nutrients on berry setting%, cluster length and cluster shoulder of Flame Seedless grapevines across 2022 and 2023 seasons

Characteristics / Treatments	Berry setting %		Cluster no./vine		Yield/vine (kg)		Cluster no./vine		Cluster weight (g)		Yield/vine (kg)	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
T1	12.3	12.6	17.0	17.6	10.7	10.9	27.0	27.0	342.0	345.0	9.2	9.3
T2	13.9	14.1	18.2	18.7	11.3	11.4	27.0	29.0	355.0	357.0	9.6	10.4
T3	15.5	15.7	19.0	19.6	11.8	11.9	27.0	31.0	364.0	366.0	9.8	11.3
T4	16.7	17.0	19.4	20.2	12.0	12.1	27.0	32.0	369.0	375.0	9.9	12.0
T5	15.4	15.6	18.8	19.4	11.7	11.9	27.0	31.0	364.0	366.0	9.8	11.3
T6	16.8	17.1	19.5	20.2	12.1	12.3	27.0	33.0	372.0	375.0	10.0	12.4
T7	18.1	18.3	20.0	20.8	12.2	12.5	27.0	34.0	377.0	381.0	10.1	13.0
T8	16.9	17.0	19.5	20.2	12.0	12.7	27.0	33.0	373.0	374.0	10.1	12.3
T9	18.3	18.5	20.1	20.9	12.4	12.7	27.0	35.0	381.0	383.0	10.3	13.4
T10	19.6	19.8	20.6	21.5	12.6	12.9	27.0	36.0	387.0	390.0	10.4	14.0
New LSD at 5%	**1.4**	**1.4**	**0.6**	**0.7**	**0.3**	**0.3**	**N.S**	**1.3**	**7.0**	**8.0**	**0.2**	**0.8**

3.2. Physical characteristics of berries

The effects of different concentrations of macro and micro nutrients on the physical characteristics of berries 'Flame seedless' grapevines grown in clay within the El-Minia Governorate during the 2022 and 2023 seasons are detailed in Table 2. The data obtained indicate that the application of 'Flame seedless' grapevine with macro or micronutrients at varying levels, administered three times, led to a significant decrease in the percentage of shot berries and increase in berries equatorial, longitudinal, average berry weight compared to the control treatment. Furthermore, the reduction in the occurrence of this unfavorable phenomenon and increase in the others was directly related to the rise in the dosage of macro or micronutrients. Nonetheless, the traits remained largely unchanged as the levels of both fertilizers increased from medium to high. The most effective treatment involved the foliar application of 1.0% of each nutrient, N, P, and K, followed by 0.75%, with no significant difference observed between the two concentrations. The table clearly indicates that the highest dose T10 (NPK at 1.0% for each component + 150 ppm Zn/B + 200 ppm Fe) significantly reduced the percentage of shot berries, yielding the lowest values of 5.5% in both seasons, respectively and highest berries equatorial (3.86 and 3.91 cm), longitudinal (1.90 and 1.92 cm), average berry weight (1.61 and 1.69 g) in both seasons, respectively. The medium concentration at T9 (NPK at 0.75% for each component + 100 ppm Zn/B + 150 ppm Fe) recorded values of (6.0 and 5.9% for shot berries), (3.79 and 3.84 cm for berries equatorial), (1.87 and 1.90 cm for berries longitudinal and (1.60 and 1.66 g for berries weight) with no noticeable change, whereas the control vines exhibited the highest significant values. This information pertains to the impact of the dual combination of macro and micro nutrients on shot berries percentage.

Table (2). Impact of applying some macro and micro nutrients on berries physical quality of Flame Seedless grapevines across 2022 and 2023 seasons

Characteristics / Treatments	Shot berries %		Average berry weight (g)		Average berry longitudinal (cm)		Average berry equatorial (cm)	
	2022	2023	2022	2023	2022	2023	2022	2023
T1	8.7	8.5	3.40	3.48	1.68	1.73	1.44	1.48
T2	7.9	7.8	3.51	3.58	1.73	1.78	1.49	1.53
T3	7.3	7.1	3.60	3.67	1.79	1.82	1.54	1.57
T4	6.8	6.7	3.67	3.74	1.82	1.84	1.56	1.60
T5	7.3	7.2	3.61	3.67	1.78	1.82	1.53	1.57
T6	6.6	6.5	3.70	3.75	1.83	1.86	1.58	1.62
T7	6.2	6.2	3.76	3.81	1.85	1.87	1.60	1.65
T8	6.7	6.6	3.71	3.75	1.82	1.86	1.56	1.61
T9	6.0	5.9	3.79	3.84	1.87	1.90	1.60	1.66
T10	5.5	5.5	3.86	3.91	1.90	1.92	1.61	1.69
New LSD at 5%	**0.6**	**0.5**	**0.08**	**0.08**	**0.04**	**0.03**	**0.03**	**0.04**

The simultaneous foliar application of NPK along with Zn, B, and Fe typically yields more significant enhancements in berry physical characteristics compared to the application of either macronutrients or micronutrients in isolation. The synergistic effects are due to the complementary roles of these nutrients in cell division, sugar transport, and hormone regulation during berry development. Research indicates that integrated nutrient management results in increased berry size, greater berry weight, and a reduced percentage of shot berries, thereby improving both yield and fruit quality.

Nitrogen is essential for vegetative growth and protein synthesis, which indirectly supports berry development. Phosphorus is vital for energy transfer and cell division, which are critical during fruit set and berry growth. Together, N and P application has been associated with increased berry size and improved fruit set, leading to a higher proportion of marketable berries (**Poposka *et al.*, 2023**). Potassium foliar applications have been demonstrated to enhance fruit expansion and berry weight and diameter. For example, research on ‘Red Roomy’ grapevines showed that foliar K, in some cases in combination, resulted in consistent increases in the size, juice content and overall quality of berries. Potassium plays multiple roles in cell division and expansion, enzyme function, and sugar transport, all of which serve to promote bigger and heavier berries (**Mostafa *et al.*, 2023**). The same study also found that adding potassium fertilizer made the cluster weight go up and the number of little or underdeveloped berries go down. This is probably because potassium helps plants make sugar and move it to developing fruits (**Chen *et al.*, 2022**).

Zinc plays a vital role in hormone synthesis and enzyme activation, both of which contribute to berry growth and development. Foliar zinc application enhances berry diameter and weight while decreasing the occurrence of shot berries by improving fertilization and early berry development (**Christensen, 2002**). Boron is critical for the growth of pollen tubes and the establishment of fruit. Adequate boron nutrition enhances fertilization, increases berry set percentage, and reduces the incidence of shot berries%. Research indicates that boron foliar applications decrease berry abnormalities and enhance uniformity in berry size (**Masoud *et al.*, 2025**). Iron plays a critical role in chlorophyll synthesis and energy production, both essential for berry development. Foliar iron application is associated with improvements in berry size, sugar content, and overall berry color and quality. Studies indicate that iron fertilization enhances the accumulation of advantageous compounds in berry skin, thereby improving overall fruit quality (**Wang *et al.*, 2024**).

3.3. Berry chemical characteristics

Data regarding the impact of various macro and micronutrients at different concentrations on the TSS%, TSS/total acidity, acidity, reducing sugar, and total anthocyanin of ‘Flame seedless’ grapevines during the 2022 and 2023 seasons (Table 3) indicated that applying macro or micro-nutrients three times to ‘Flame seedless’ resulted in a significant increase in berry chemical parameters compared to the control treatment in both experimental seasons. The data obtained clearly indicate that the enhancement of berries chemical traits occurred gradually and in parallel with the increasing concentrations of NPK. In the analysis, the vines that underwent three sprays with the highest concentration (T7; 1.0%) exhibited the highest TSS%, TSS/total acidity, reducing sugar, and total anthocyanin recording (21.3-21.7%, 36.6-37.5, 17.2-17.7% and 27.6-27.8 mg/100g, respectively in two seasons, and reduction in total acidity recording 0.582- 0.578% during two seasons. This was closely followed by T6, which utilized NPK at a concentration of 0.75% for each element. In contrast, untreated vines (T1) exhibit the lowest TSS% (19.1-19.4%), TSS/total acidity (26.6-27.1), reducing sugar (15.4-16.0%), and total anthocyanin (25.3-25.5 mg/100g), with a rise in acidity (0.719-0.715%). The data presented in the Table indicate that the dual application of macro and micro-nutrients through foliar spray on Flame seedless vines, at various concentrations, significantly enhanced the chemical quality of the berries in comparison to the untreated vines. The highest mean value of the chemical parameters was recorded with T10 (NPK at 1.0% for each component + 150 ppm Zn/B + 200 ppm Fe), followed by T9 (NPK at 0.75% for each component + 100 ppm Zn/B + 150 ppm Fe), with no significant difference observed between the two.

Research indicates that foliar application of macronutrients (NPK) and micronutrients (Zn, B, Fe) significantly enhances the chemical quality attributes of grape berries. The observed enhancements include increased total soluble solids (TSS), optimized acidity, a higher TSS/acidity ratio, elevated reducing sugar content, and greater anthocyanin accumulation, all of which are essential for fruit flavor, marketability, and nutritional value.

The application of potassium, an essential element of NPK fertilizers, significantly affects the enhancement of total soluble solids (TSS) and the reduction of sugar content in grape berries. Potassium enhances the movement and concentration of sugars in fruit, leading to sweeter berries with elevated TSS values, which serve as a significant measure of fruit ripeness and consumer preference (**Ben Yahmed and Ben Mimoun 2018**). Nitrogen and phosphorus enhance sugar synthesis and energy transfer, thereby improving berry sweetness and quality (**Khalil *et al.*, 2018**). Foliar sprays with micronutrients, particularly iron, zinc and boron, improve photosynthetic activity and carbohydrate metabolism, resulting in increased total soluble solids and reducing sugar levels (**Ali *et al.*, 2021**). Fruit acidity represents a significant quality parameter influenced by nutrient management. The application of potassium reduces berry acidity by facilitating the neutralization of organic acids during ripening. Additionally, boron and zinc affect acid metabolism, contributing to an optimal acid balance (**Singh and Usha, 2001**). Anthocyanins, which cause the red and purple coloring in grape skins, are essential for both visual appeal and antioxidant activity. Potassium promotes anthocyanin production, resulting in deeper berry color and more nutritional value (**El-Badawy, 2019**). Furthermore, foliar boron and zinc administration has been found to boost anthocyanin content by promoting the enzymatic pathways involved in pigment formation (**Abou-Zaid and Shaaban, 2019**). Iron spraying boosted the quantities of soluble sugars and anthocyanins in berries, according to **Shi *et al.* (2017).**

Table (3). Impact of applying some macro and micro nutrients on berries chemical quality of Flame Seedless grapevines across 2022 and 2023 seasons

Characteristics / Treatments	TSS%		Total acidity%		TSS/acidity ratio		Reducing sugar%		Total anthocyanin mg/100g FW	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
T1	19.1	19.4	0.719	0.715	26.6	27.1	15.4	16.0	25.3	25.5
T2	19.8	20.0	0.680	0.675	29.1	29.6	16.0	16.5	26.1	26.2
T3	20.4	20.5	0.641	0.635	31.8	32.3	16.5	16.9	26.7	26.9
T4	20.8	20.8	0.619	0.610	33.6	34.1	16.8	17.2	27.1	27.2
T5	20.5	20.7	0.645	0.640	31.8	32.3	16.5	17.0	26.7	26.8
T6	21.0	21.3	0.610	0.605	34.4	35.2	17.0	17.4	27.3	27.4
T7	21.3	21.7	0.582	0.578	36.6	37.5	17.2	17.7	27.6	27.8
T8	21.1	21.3	0.615	0.605	34.3	35.2	16.9	17.4	27.2	27.4
T9	21.7	21.9	0.580	0.575	37.3	38.1	17.4	17.9	27.8	28.1
T10	22.1	22.3	0.551	0.547	40.1	40.8	17.7	18.2	28.2	28.4
New LSD at 5%	**0.5**	**0.5**	**0.03**	**0.03**	**2.9**	**2.8**	**0.4**	**0.4**	**0.5**	**0.5**

4. Conclusion

Based on the current field trials, applying foliar sprays thrice through the growing; the onset of growth, immediately following berry set, and one months thereafter at rate of 0.75% NPK + 100 ppm Zn/B + 150 ppm Fe is superior to higher rates for Flame Seedless grapevines under Minia conditions. This approach achieves optimal vine health and productivity while ensuring better economic returns for growers.

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تحسين إنتاجية و جوده كرمات العنب فليم سيدلس بالرش الورقى بالعناصر الكبرى و الصغرى

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الموجز

أجريت تجربه حقليه خلال عامى ٢٠٢٢ و ٢٠٢٣ بمزرعه خاصة تقع غرب مركز سمالوط، محافظة المنيا لدراسة تأثير الرش الورقى ثلاث مرات بتركيزات مختلفه من العناصر الكبرى و الصغرى إما بمفردها أو ومجتمعه على إنتاجية و جودة عنب فليم سيدلس. أظهرت النتائج أن الرش الورقى المشترك للعناصر الكبرى و الصغرى أدى إلى تحسين كبير فى صفات المحصول مثل (نسبة العقد، عدد العناقيد / الكرمة، وزن العنقود، طول العنقود، عرض العنقود، المحصول / الكرمه بالكجم) مقارنه الكنترول. حيث سجلت أعلى القيم عند الرش الورقى بتركيز ١% لكل من النيتروجين و الفوسفور و البوتاسيوم مع ١٠٠ جزء فى المليون زنك او بورون مع ٢٠٠ جزء فى المليون حديد يليها تركيز ٠,٧٥% لكل من النيتروجين و الفوسفور و البوتاسيوم مع ٧٥ جزء فى المليون زنك او بورون مع ١٥٠ جزء فى المليون حديد دون وجود فرق معنوي بينهما، حيث حسنت أيضا صفات الجوده فإزداد وزن و طول و قطر الحبات و النسبة المئويه للمواد الصلبه الذائبة الكليه، المواد الصلبه الذائبة الكليه/الحموضه، محتوى السكريات المختزله و المحتوى الكلى للأنثوسيانين مع إنخفاض فى نسبة الحبات الصغيره/العنقود و الحموضه الكلية. و بالتالى تشير النتائج إلى أن الإدارة المتكامله للمغذيات الكبرى و الصغرى تحسن إنتاجية و جودة عنب فليم سيدلس تحت ظروف محافظة المنيا.

الكلمات المفتاحية: عناصر كبرى، عناصر صغرى، محصول، جوده و عنب فليم سيدلس.