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Article

Impact of Magnesium Sulphate and Boric Acid on Yield and Quality of Red Roomy Grapevines

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Abstract: This research involved 14-year-old Red Roomy grapevines. The experimental site was established at a private farm in West Matay Center, Minia Governorate, to investigate the effects of different concentrations of magnesium sulphate (0.05, 0.1, and 0.2%) and boric acid (0.025, 0.05, and 0.1%), along with their interactions, on the yield and the physical and chemical quality of Red Roomy grapevines during the 2023 and 2024 seasons. This study utilized a randomized complete block design comprising ten treatments with three duplicates. The findings indicated that the application of magnesium sulphate was more effective than boric acid, especially at a concentration of 0.2%, followed by 0.1%. The application of 0.1% boric acid combined with 0.2% magnesium sulphate proved to be the most effective treatment for the studied traits, closely followed by the combination of 0.05% boric acid and 0.1% magnesium sulphate, which showed no significant differences. The combination of middle concentrations was demonstrated the effectiveness economical in enhancing the yield, as well as the physical and chemical quality of Red Rooy grapevines under the Minia Governorate.

Key words: Magnesium sulphate, boric acid, yield, quality and Red Roomy grapevines

1. Introduction

The grapevine (*Vitis vinifera* L.) is recognized as the most economically significant crop on a global scale and is the third most important crop in Egypt. Table grapes are the most frequently grown grape varieties in Egypt, and they are all composed of European grape cultivars (**Mohamed *et al.*, 2019**). The region in Egypt designated for grape production spans 186735 feddans, with a productive area of 175245 feddans, yielding a total of 1715410 tons. The cultivated land in Minia Governorate reached 210809 feddans, with a productive area of 20852 feddans, yielding a total of 205244 tons (**MALR, 2023**). The primary issue encountered by producers of the Red Roomy grape cultivar is the decrease in berry set, which results in loose clusters and a reduction in berry quantity. The clusters are perceived as unfavorable from the consumer's perspective (**Abou-Zaid and Shaaban, 2019).**

Since nutrition affects berry composition, crop output, vine development, and eventually must quality, it is still a crucial component of vineyard management. Since nutritional needs must be tailored to a variety of factors, such as grape variety, rootstock, vine age, soil type and characteristics, water and irrigation supply, production and quality objectives, and management history, a "one program fits all" approach is not feasible. For maximum effectiveness, the nutrients in the soil and plants need to be continuously evaluated and maintained. Each of the mineral elements is necessary to complete the vine's life cycle, even though they are required in varying amounts. Vine consumption of macronutrients as nitrogen, phosphorus, potassium, and magnesium is comparatively high. Even though they are equally important, micronutrients like boron, iron, manganese, zinc, and molybdenum are required in extremely small amounts. When one or more of these components is lacking, vines may grow or yield less and be more vulnerable to winter damage and disease. Other issues include fruit with a low or high pH, poor color, low phenolic, blocked fermentations, and unwanted flavors could also arise from this. Therefore, for the best vine, the availability of vital nutrients is crucial (**Joshi, 2022**).

The application of micronutrients like boron through foliar spraying is a more effective method for meeting the nutritional needs of trees, as it enhances absorption through the stomata and epidermis of leaf tissue while minimizing chemical buildup in the soil. Moreover, the application of nutrient sprays has proven to be an effective method for improving fruit set, yield, and quality, as well as enhancing fruit retention (**Bons and Sharma, 2023**). Boron is a crucial micronutrient for fruit trees, such as grapes. It is essential in multiple growth and fruiting stages, including pollination, fertilization, and fruit set processes, and significantly contributes to carbohydrate metabolism (**Hadi and Saleh, 2021**). Boron is a crucial micronutrient for higher plants, playing significant roles in sugar transport, carbohydrate metabolism, cell wall composition, and respiration. It plays a crucial role in trees by inducing pollen tube growth, enhancing fertilization, and increasing fruit sets (**Alila, 2023**). Boron has been widely recognized by specialists as essential for the growth and fruiting of grape cultivars **(Ahmad *et al.*, 2014; Tadayon and Moafpourian, 2019**). Boron is recognized for its essential role in advancing the fruiting of grapevines (**Abou-Zaid and Shaaban, 2019).**

Magnesium is essential for various physiological processes in plants. Numerous developed nations are reassessing their agricultural policies to diminish or eradicate chemical substances (**Adnan and Anjum, 2021**). The application of magnesium via foliar methods is essential for various physiological and biochemical processes in plants, including protein synthesis, starch metabolism, and energy transfer (**Adnan *et al.*, 2020**). Additionally, magnesium serves as a catalyst in reduction and oxidation processes within plant tissues, enhancing drought tolerance (**Adnan *et al.*, 2021). Kleczkowski and Igamberdiev (2021)** indicate that magnesium is essential for the activation of enzymes that play a role in respiration, photosynthesis, and nucleic acid synthesis. The chloroplast complex, responsible for light absorption, includes magnesium as the central atom of the chlorophyll molecule, which is crucial for the photosynthesis of carbon dioxide in plants (**Cakmak and Kirkby 2008**).

This study aimed to investigate the impact of varying levels of magnesium sulphate and boric acid sprays on the growth, leaf composition, yield, and fruit quality of Red Roomy grapevines under the Minia Governorate conditions.

2. Materials and Methods

2.1. Experimental vineyard

This study utilized 14-year-old Red Roomy grapevines. The experimental site was established at a private farm in West Matay Center, Minia Governorate, to examine the effects of varying concentrations of magnesium sulphate and boric acid, as well as their interactions, on yield, and berry quality of Red Roomy grapevines during the 2023 and 2024 seasons. Soil samples were collected from depths of 0–30 cm to assess various physical and chemical characteristics, following the methodology outlined by **Wilde *et al.* (1985)** in Table (A). Irrigation was conducted using Nile water through a surface irrigation system.

Table (A). Physio-chemical analysis of the tested soil

Soil characters		2023/2024
Particle size distribution (%)	Sand	3.12
	Silt	35.80
	Clay	61.08
	Texture class	Clay
EC ppm (1:2.5 extract)		292
pH (1:2.5 extract)		7.94
Organic matter %		2.36
$CaCO_3$ %		2.49
Soil nutrients	Total N (%)	0.20
	Available P (ppm)	5.13
	Available K (ppm)	495.0
	Zn (ppm)	2.3
	Fe (ppm)	2.7
	Mn (ppm)	3.9
	Cu (ppm)	0.15

Vines were spaced 2 by 3 meters apart. Pruning occurred in the second week of January, and the experimental vines were subjected to standard agricultural practices as recommended. The vine load was adjusted to 72 buds per vine, consisting of sixteen fruiting spurs with four eyes each, in addition to four replacement spurs with two eyes each.

2.2. Experimental design

Experiments were performed using a randomized complete block design with three replications, employing one vine per treatment across two seasons, the treatments were as follows:

1) Control (spray with tap water).
2) Boric acid (BA at 0.025%).
3) Boric acid (BA at 0.05%).
4) Boric acid (BA at 0.1%).
5) Magnesium sulphate (Mg-S at 0.05%).
6) Magnesium sulphate (Mg-S at 0.1%).
7) Magnesium sulphate (Mg-S at 0.2%).
8) BA at 0.025%+ Mg-S at 0.05%.
9) BA at 0.05%+ Mg-S at 0.1%.
10) BA at 0.1%+ Mg-S at 0.2%.

The 30 chosen vines were treated with sprays three times until runoff occurred: the first application was at the onset of the vegetative stage, the second followed after fruit set, and the third was administered one month later.

2.3. Measurements

Yield and cluster components

- At harvest time all clusters on the vines were picked, the number of clusters/vine and cluster weight, then the yield (kg/vine) were recorded by multiply the previous parameters.

- Cluster dimensions (length and shoulder in (cm)).

- 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:

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

Physical and chemical properties of berries

- The shot berry proportion was calculated by dividing the percentage of berries in each cluster by the total number of berries in all clusters, and then multiplying the result by 100.

- A sample of 100 berries was taken from each replicate, and the following measurements were determined: berry weight, berry length, and diameter.

- Furthermore, the chemical properties of the berry juice were assessed: the percentage of total soluble solids (TSS) was measured using a hand refractometer, and the total titratable acidity was determined through titration with 0.1N sodium hydroxide in the presence of phenolphthalein dye. Furthermore, total sugar was measured in accordance with **A.O.A.C. (2000**), and the T.S.S/acid ratio was calculated. Additionally, the total anthocyanin content in berry skin was evaluated using a spectrophotometer, adhering to the methodology established by **Yilidz and Dikmen (1990).**

2.4. Statistical analysis

The data were analyzed using ANOVA, and the means were compared using the NEW LSD test at the 5% level, as per **Mead *et al.* (1993).**

3. Results and Discussion

3.1. Yield and cluster characteristic

Evaluate the effect of foliar application of boric acid and magnesium sulphate at different doses on the production of "Red Roomy" grapevines using parameters like berry setting percentage, average cluster weight, yield per vine, average cluster length and width, and number of clusters per vine, comparing to the control, indicated at Table 1,

The results presented in Table 1 indicate a significant variation in yield and cluster parameters across the foliar treatments of BA and Mg-S at various levels. Results indicated that amending Red Roomy grapevines with Mg-S spraying significantly enhanced mentioned parameters compared to BA. The optimal yield and cluster traits results were achieved with treatments of 0.2% and 0.1% Mg-S, showing no significant difference between the two concentrations. The combination of treatments resulted in positive effects on the traits. The same results were consistent across both seasons. The application of BA (0.1%) combined with Mg-S (0.2%) on Red Roomy grapevines yielded the highest results. From an economic perspective, no significant enhancement in cluster parameters or yield was observed with increased spraying concentration of the vines. The optimal results, from an economic standpoint, were achieved by applying BA (0.05%) combined with Mg-S (0.1%).

Table (1). Impact of sprinkle with boric acid and magnesium sulphate on cluster number/vine, cluster weight (g) and yield (kg)/vine of Red Roomy grapevines across 2023 and 2024 seasons

Characteristics / Treatments	Cluster number/vine		Cluster weight (g)		Yield/vine (kg)		Berry setting %		Cluster length (cm)		Cluster shoulder (cm)	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	24.0	23.0	330.0	328.0	7.9	7.5	5.7	5.6	19.7	20.0	12.5	12.2
BA (0.025%)	25.0	26.0	341.0	340.0	8.5	8.8	7.4	7.1	20.9	21.1	13.4	13.2
BA (0.05%)	25.0	28.0	350.0	350.0	8.8	9.8	8.9	8.5	21.8	21.9	14.2	13.8
BA (0.1%)	25.0	29.0	358.0	354.0	9.0	10.4	9.8	9.3	22.1	22.3	14.5	14.0
Mg-S (0.05%)	26.0	28.0	351.0	351.0	9.1	9.8	9.0	8.5	21.7	21.8	14.0	14.0
Mg-S (0.1%)	26.0	31.0	361.0	363.0	9.4	11.2	10.4	9.8	22.3	22.4	14.5	14.4
Mg-S (0.2%)	26.0	32.0	368.0	371.0	9.6	11.8	11.2	10.5	22.6	22.7	14.7	14.6
BA (0.025%) + Mg-S (0.05%)	26.0	30.0	362.0	361.0	9.4	10.8	10.5	10.1	22.2	22.3	14.6	14.5
BA (0.05%) + Mg-S (0.1%)	26.0	32.0	371.0	371.0	9.6	11.9	11.8	11.3	22.6	22.8	15.2	15.1
BA (0.1%) + Mg-S (0.2%)	26.0	33.0	379.0	380.0	9.9	12.5	12.6	12.1	22.8	23.2	15.5	15.2
New LSD at 5%	**N.S**	**2.0**	**9.0**	**9.5**	**0.4**	**0.7**	**1.0**	**0.9**	**0.4**	**0.5**	**0.4**	**0.3**

BA: Boric acid Mg-S: Magnesium sulphate

The application of nutrients via foliar methods resulted in a significant increase in all yield-related attributes, with the highest values consistently recorded at the maximum nutrient doses applied. The induction of flowers into fruits through foliar nutrient treatment may influence increases in bunch number per vine, bunch length, berry number per bunch, berry diameter, and bunch weight, ultimately contributing to enhanced grapevine yield (Table 1). The observed increases in yield attributes following foliar application of B may be linked to its synthetic role in various hormones and other metabolic processes. The positive impact of boron on growth parameters and vine nutritional status is evident in the increased cluster weight and dimensions, consequently enhancing yield per vine. Boron positively affects the germinability of grapevine pollen grains and likely serves as a specific nutrient for generative growth during berry setting in the cultivar, as evidenced by the increase in both the number and percentage of normal berries (**Mohamed *et al.*, 2017**). The positive impact of boron on yield may be ascribed to its significant roles in enhancing growth parameters, nutritional status of the vines, berry set, number of clusters per vine, and the weight of clusters and berries. Previous studies indicate that foliar application of boron enhanced fruit yield in Naval oranges (**Chen *et al.*, 2014**), and similar observations concerning boron application have been documented in grapevines (**Singh and Usha, 2001; Wang *et al.*, 2021**).

The positive impact of magnesium application on grapevine productivity is ascribed to its function in improving plant metabolism, as evidenced by improvements in both berry yield and quality. As a result of magnesium's critical function in the synthesis of organic molecules, including carbohydrates and lipids, foliar fertilizers, such as magnesium, increase yield and its components, which are subsequently transported to the reproductive organs (**Marschner, 2011**). **Bybordi and Shabanov (2010)** and **Zlámalová *et al.* (2015)** demonstrated that the foliar application of Mg significantly increased yields in comparison to the untreated control. The results in this context are in agreement with the research conducted by **Farag and Abd El-All (2019), Qaoud and Mohamed (2019), and Eisa *et al.* (2023)**.

3.2. Berry physical characteristics

Table 2 present the morphophysical parameters of the grapevine "Red Roomy," encompassing shot berry, average berry weight, longitudinal, and equatorial measurements. The morphophysical parameters are analyzed in comparison to the control treatments across the 2023 and 2024 seasons to assess the effects of foliar application of BA and/or Mg-S at varying concentrations. These parameters are essential for effective marketing at local, regional, and global levels.

The data tabulated in Table (2) elucidate the impact of chemical compounds application on the physical berry quality of Red Roomy grapevines. The findings revealed markedly significant distinctions across all treatments in the 2023 and 2024 seasons. The results obtained elucidated that the increments in average berry weight, longitudinal, equatorial and reduction in shot berry% were notably more significant with the application of Mg-S at a concentration of 0.2% in comparison to the use of BA, whereas the control treatment yielded the lowest average berry weight, longitudinal, equatorial and highest shot berry across both seasons. The interplay between BA and Mg-S treatments exhibited a high significance across all concentrations, while showing no significant effect at the two higher levels concerning traits. The highest mean values were indicated at 0.1% BA and 0.2% Mg-S, which recorded lowest shot berry.

Table (2). Impact of sprinkle with boric acid and magnesium sulphate on berries physical quality of Red Roomy grapevines across 2023 and 2024 seasons

Characteristics / Treatments	Shot berries %		Berry weight (g)		Berry longitudinal (cm)		Berry equatorial (cm)	
	2023	2024	2023	2024	2023	2024	2023	2024
Control	9.7	9.5	4.95	5.06	2.13	2.15	1.83	1.80
BA (0.025%)	8.6	8.1	5.15	5.24	2.22	2.23	1.90	1.88
BA (0.05%)	7.7	7.0	5.29	5.40	2.30	2.30	1.96	1.94
BA (0.1%)	7.1	6.3	5.40	5.53	2.36	2.35	2.00	1.99
Mg-S (0.05%)	7.8	7.3	5.30	5.40	2.29	2.31	1.95	1.95
Mg-S (0.1%)	7.0	5.4	5.43	5.57	2.36	2.37	2.00	2.02
Mg-S (0.2%)	6.5	4.7	5.53	5.71	2.41	2.41	2.03	2.06
BA (0.025%) + Mg-S (0.05%)	6.9	6.4	5.43	5.55	2.36	2.38	2.01	2.01
BA (0.05%) + Mg-S (0.1%)	6.2	5.5	5.55	5.70	2.44	2.45	2.08	2.07
BA (0.1%) + Mg-S (0.2%)	5.6	4.9	5.66	5.84	2.50	2.50	2.12	2.12
New LSD at 5%	**0.7**	**0.8**	**0.12**	**0.15**	**0.07**	**0.06**	**0.05**	**0.06**

BA: Boric acid Mg-S: Magnesium sulphate

The beneficial effects of boron on biosynthesis, nitrogen metabolism, and pollen germination may enhance berry setting (**Hegazy *et al.*, 2018**), which reflected to the physical quality. Several investigation emphasized the outstanding effect of using boron on the physical quality for fruits as **Abou-Zaid and Shaaban (2019); Abdelaziz *et al.* (2021); Kupe and Hacimuftuoglu (2023).**

The use of magnesium improved the physical characteristics of berries because of its crucial function in the composition of chlorophyll molecules, thus encouraging chlorophyll production **(Papadakis *et al.* 2023).** The application of magnesium in various forms resulted in improved physical berry quality across diverse grapevine varieties, as reported by **Farag and Abd El-All (2019), Qaoud and Mohamed (2019), Eisa *et al.* (2023), and El-Katawy *et al.* (2024).**

3.3. Berry chemical quality characteristics

As a consequence of the foliar application of BA and / or Mg-S thrice at varying concentrations during the 2023 and 2024 seasons, the average values of the chemical quality characters (TSS%, total acidity, TSS/acidity ratio, reducing sugar, and total anthocyanin) in grapevine cv. 'Red Roomy' grapevines are illustrated in Table 3.

The analysis of the solo application of BA and/or Mg-S at varying levels, as presented in Table (3), indicates that a significant increase in the TSS%, TSS/acidity ratio, reducing sugar, total anthocyanin and decrease in total acidity were observed in both seasons when compared to the control group. Vines treated with 0.2% Mg-S exhibited a notable increase in the chemical traits except a reduction in total acidity while those treated with 0.1% showed similar results without clear differences between the two concentrations. A notable increase in the TSS%, TSS/acidity ratio, reducing sugar, and total anthocyanin and reduction in total acidity were observed when applying a combination of BA and Mg-S, in contrast to the individual addition or control vines. A notable increase in the traits except total acidity decreased were observed with the application of 0.1% BA + 0.2% Mg-S. This was closely aligned with the results from vines treated with 0.05% BA + 0.1% Mg-S. The other treatments exhibited medium ratios.

The significant role of boron in the production and translocation of sugars may lead to increased sugar accumulation in the berries, resulting in enhanced maturity and improved quality. the findings about the enhancement of boron's impact on the chemical parameters of the berries align with those acquired by **Abdelaziz *et al.* (2021); Ali *et al.* (2021); Abobatta *et al.* (2024).**

Malakouti (2006) showed that the use of magnesium solution enhanced the movement of photosynthetically produced substances from the leaf to the grape fruit. **Bybordi and Shabanov (2010)** demonstrated that increased magnesium application resulted in elevated leaf chlorophyll content, thereby enhancing photosynthesis and significantly increasing total soluble solids percentages. Additionally, magnesium is essential for glucose metabolism and cellular division (**Ilyas *et al.* 2014**). **Mostafa *et al.* (2017), Farag and Abd El-All (2019), Qaoud and Mohamed (2019), and Eisa *et al.* (2023)** all demonstrated improved chemical parameters in various grapevine varieties as a consequence of foliar magnesium sprays at varying doses.

Table (3). Impact of sprinkle with boric acid and magnesium sulphate on berries chemical quality of Red Roomy grapevines across 2023 and 2024 seasons

Characteristics / Treatments	TSS%		Total acidity%		TSS/acidity ratio		Total sugar%		Total anthocyanin mg/100g FW	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	18.3	18.4	0.720	0.722	25.42	25.48	17.0	17.1	2.10	2.13
BA (0.025%)	19.0	19.1	0.700	0.700	27.14	27.29	17.6	17.7	2.22	2.24
BA (0.05%)	19.0	19.8	0.679	0.680	28.87	29.12	18.1	18.2	2.32	2.34
BA (0.1%)	20.0	20.2	0.666	0.667	30.03	30.28	18.4	18.6	2.39	2.42
Mg-S (0.05%)	19.5	19.7	0.684	0.681	28.51	28.93	18.0	18.2	2.33	2.34
Mg-S (0.1%)	20.2	20.2	0.664	0.666	30.42	30.33	18.5	18.7	2.45	2.43
Mg-S (0.2%)	20.5	20.5	0.650	0.654	31.5	31.35	18.7	19.0	2.51	2.50
BA (0.025%) + Mg-S (0.05%)	20.1	20.3	0.667	0.665	30.13	30.53	18.4	18.7	2.43	2.45
BA (0.05%) + Mg-S (0.1%)	20.6	20.9	0.650	0.648	31.64	32.25	19.0	19.3	2.54	2.55
BA (0.1%) + Mg-S (0.2%)	21.0	21.3	0.637	0.635	32.97	33.54	19.3	19.7	2.61	2.63
New LSD at 5%	**0.5**	**0.5**	**0.015**	**0.014**	**1.30**	**1.31**	**0.4**	**0.5**	**0.08**	**0.09**

BA: Boric acid Mg-S: Magnesium sulphate

Conclusion

Based on the results presented and the same conditions of this research, it can be concluded that the application of Red Roomy grapevines with a mixture of 0.05% boric acid and 0.1% magnesium sulphate, administered three times—at the onset of growth, immediately after berry setting, and one month later—yielded the most favorable outcomes regarding yield, its components, and chemical composition.

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تأثير الرش الورقى بسلفات الماغنيسيوم و حامض البوريك على إنتاجية و جودة كرمات العنب الرومى الأحمر

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الملخص العربى

إستخدمت الدراسه الحاليه كرمات العنب الأحمر بعمر ١٤ عام مزروعه فى مزرعة خاصة غرب مركز مطاى – محافظة المنيا لدراسة تأثير تركيزات مختلفه للرش الورقى بسلفات الماغنيسيوم (٠,٠٥، ٠,١ و ٠,٢%) و حامض البوريك (٠,٠٢٥، ٠,٠٥ و ٠,١%) و تفاعلاتهما على إنتاجية و جودة العنب الرومى الأحمر خلال موسمى ٢٠٢٣ و ٢٠٢٤م، فى تصميم قطاعات كاملة العشوائية تحتوى على ١٠ معاملات فى ثلاث مكررات. أوضحت التجربه أن الرش الورقى بسلفات الماغيسيوم كان الأفضل من حامض البوريك و خاصة عند تركيز ٠,٢% يليه ٠,١%، ووجد أن الرش بإستخدام تركيز ٠,١% حامض بوريك + ٠,٢% سلفات ماغنيسيوم كان الأكثر تفوقا فى الحصول على أفضل الصفات يليه الرش بالتركيز الأقل ٠,٠٥% حامض بوريك + ٠,١% سلفات ماغنيسيوم بدون ملاحظة أى فرق معنوي بين التركيزين. لذلك، خلال التجربه أثبت أن المعاملات المشتركه بالتركيزات المتوسطة يعتبر نهج إقتصادى فعال و قوى لتعزيز النمو و الإنتاجية و الجوده الفيزيائية و الكيميائية للعنب الرومى الأحمر تحت ظروف محافظة المنيا.

الكلمات المفتاحية: سلفات ماغنيسيوم، حامض بوريك، محصول، جودة و عنب رومى أحمر.