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Research Article

Monopotassium Phosphate Foliar Application and Bunch Thinning Enhances Growth and Physical Attributes of 'Flame Seedless' Grapes

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Abstract:

The present investigation was carried out during two seasons in 2023 and 2024; ten-year-old "Flame Seedless" grapevines were grafted on "Freedom" grape rootstocks at the El-Baramon experimental farm in the Dakahlia Governorate. The whole vine was sprayed with monopotassium phosphate at 3 g/L until runoff at three different times: 2 weeks after the beginning of vegetative growth, when shoot length reached about 25–30 cm, after berry set, and at the beginning of berry coloring (véraison stage), bunch thinning was performed by leaving 30 bunches per vine after the fruit set .The results showed that all conducted treatments were effective in improving vegetative growth and physical properties of bunches and berries of 'Flame Seedless' as compared with the control. Moreover, foliar application with monopotassium phosphate (MKP) at a rate of 3 g/l and thinning 30 bunches per vine in grapevine improvement vegetative growth, cluster weight, cluster length, width, berry weight, firmness, length, and width.

1. Introduction

The grape (*Vitis vinifera* L.) is one of the most significant, lucrative, well-liked, and healthful fruit crops worldwide. In the marketing year 2023-2024, the output of table grapes in Egypt is predicted to reach 1.9 million metric tons, with an estimated export volume of 170,000 metric tons (FAO, 2023), grape occupies the second position after citrus, production and exportation.

'Flame Seedless' grape is considered one of the most important grape cultivars and was early in Egypt. This is basically due to its high acceptance by both local consumers and exporters. Small-sized berries and uneven color clusters are one of the main drawbacks for local growers of Egypt. Overcoming these problems would lead to improving the market price for local consumption and exportation. Hence, it holds considerable importance for local and international markets, particularly for exports to European countries (El-Boray et al., 2018; Elaidy et al., 2024). Given the fact that most global markets do not have access to a year-round supply of grapes in Egypt, early maturation is a key component of Egypt's grape export program. The grape growers gave great attention to all cultural practices to improve the yield and berry quality (Belal et al., 2016; Mira et al., 2024).

The appearance of table grapes must primarily attract consumers, and it is a response to the spread of any cultivar. Attractive factors for table grapes are berry and cluster size, shape, sugars, and berry color (Özer et al., 2012). Good quality table grapes represent a combination of medium-sized clusters of uniformly large and perfect berries with their characteristic color and pleasing flavor (Winkler et al., 1974). Several cultural practices can be used to achieve quality, e.g., canopy management and cluster thinning. Cluster and berry thinning are management practices to adjust over-cropping and represent an approach to improving quality. The amount of fruit load per plant compromises the size of the clusters and thus the accumulation of sugars (Santesteban et al., 2011).

Thinning has a certain status as a technique without special skills for improving grapevine quality and yield regulation. With the removal of some clusters, the leaf area per yield unit concerned will be higher; hereby, the grape quality will be improved. The regulation of the yield can lead to further advantages, where the ratio between vegetative and generative performance of the vines will be improved, the condition of the plants will be better, the diseases can be reduced, and the growth of the shoots can be promoted. Thus, cluster thinning has a direct effect on the relationship between nutrient supply and vine requirements, which means that with fewer grape clusters on a vine, the photosynthetic assimilation is improved, leading to an increase in the quality of grapes (Reynolds et al., 1994).

Monopotassium phosphate (MKP) fertilizer is a compound fertilizer that contains two macronutrients, namely Phosphate (P) 52% and Potassium (K) 34%. K and P advance maturity and ripening fruit as well as improve the capacity to synthesize starch (Bose et al., 1988). For instance, the application of the fertilizer MKP (0-52-34) was reported to increase crop tolerance to biotic stresses' tolerance (Reuveni et al., 1994). Monopotassium phosphate (KH_2PO_4) is a salt compound that is used as a food additive. KH_2PO_4 has been approved as "generally recognized as safe" (GRAS) for use in human food by the U.S. Food and Drug Administration (FDA). Thus, the purpose of this study was to use environmentally friendly ways to enhance physical characteristics of fruits of 'Flame Seedless' grape by using bunch thinning at 30 bunches per vine and foliar application of monopotassium phosphate.

2. Materials and methods

2.1. Plant Materials and Experimental Procedure

During two seasons in 2023 and 2024, ten-year-old 'Flame Seedless' grapevines grafted on "Freedom" grape rootstocks were studied in clay soil and a flood irrigation system on the El-Baramon experimental farm in the Dakahlia Governorate. Grapevines were cultivated using a quadrilateral cordon training system of short spurs in a Spanish baron trellis. All grapevines were spur pruned by the third week of January in both seasons, retaining 68 buds per vine (four cordons, each with three five-bud spurs and one two-bud renewal spur).

2.2. Experimental Design and Treatments

This experiment included 36 uniform grapevines planted at a spacing of 2 m × 3 m and free of any physiological diseases or nutrient deficiencies. The control consisted of 40 bunches/vine and sprayed with water. Treatments were placed in a randomized complete block design (RCBD) system with three replicates, and each replicate was represented by three vines. In both seasons, the same nine vines were subjected to the same treatment as follows:

1. Control (leaving 40 bunches /vine).
2. Foliar with monopotassium phosphate (MKP) at 3 g/L with leaving 40 bunches /vine.
3. Bunch thinning (leaving 30 bunches /vine) .
4. Foliar with MKP at 3g/L+ bunch thinning by leaving 30 bunches/vine.

The whole vine was sprayed with MKP until runoff at three different times: 2 weeks after the beginning of vegetative growth, when shoot length reached about 25–30 cm, after berry set, and at the beginning of berry coloring (véraison stage). Bunch thinning was performed after the fruit set (Ahmad, 2016).

2.3. Measurements

2.3.1. Vegetative growth parameters

Vegetative growth parameters were determined two weeks after véraison stage.

2.3.1.1. Shoot length

four non-fruiting shoots off the renewal spurs were randomly marked; two shoots at each side of the vine to measure shoot length, using a 1000 cm wind-up measuring tape (Fisher Scientific, Waltham, MA, USA), in the middle of May, and calculate the shoot length (cm).

2.3.1.2. Shoot diameter

It was measured by using vernier caliper at winter pruning.

2.3.1.3. Number of leaves/ shoot

On March 1st, ten shoots per vine (among spring flush), uniform in diameter and length, were identified. At the end of each season, the number of leaves/shoots was counted.

2.3.1.4. Yield

At the harvest time of each season, the bunch per vine was recorded. Six bunches/replicate were randomly harvested when the TSS attained about 16% in the untreated vine and measured the yield components as follows: Individual vine yields were weighed and the average yield per vine was measured by multiplying the average cluster weight by the number of clusters/vine. The yield per feddan (tons) was calculated by multiplying the yield per vine by the number of vines in feddan.

2.3.2. Bunch and berry physical parameters

At harvest, on the first of June, a representative sample of Six bunches from each replication was taken to determine the following parameters:

2.3.2.1. Bunch weight

Bunch weight (g) was calculated and recorded

2.3.2.2. Bunch length and width

Bunch length and width (cm) was also measured using a 40-cm stainless steel ruler (Apuxon, Shenzhen, Guangdong, China) from the uppermost berry to the most bottom berry and then average length and width was calculated

2.3.2.3. 100 Berry weight

Berry weight (g) was determined by weighing 100 randomly selected berries per bunch using the bench-top digital scale.

2.3.2.4. Berry length and width

2.3.2.5. Berry firmness

From this set, 20 berries were used to determine berry firmness twice at the equatorial area of the berry (Watkins and Harman, 1981) using a FT-02 hand-held digital penetrometer, fitted with a 2 mm plunger tip (QA Supplies LLC, Norfolk, VA, USA), and firmness was expressed in Newton (N)

2.4. Statistical analysis

Data were first examined utilizing the Shapiro-Wilk and Levene testing for numerical normality and homogeneity of variance, respectively. Before doing the analysis of variance (ANOVA), the percentage data were first converted to the values of the Arcsine square root. The outcomes were then shown as back-transformed means. The CoStat software packaging, version 6.311 (CoHort software, Monterey, CA, USA), was used for carrying out the ANOVA. Tukey's honestly significant difference (HSD) test was used to conduct mean comparisons at probability ($p < 0.05$) (Snedecor and Cochran, 1990).

3. Results

3.1. Vegetative growth parameters

Vegetative growth parameters (shoot length, shoot diameter, and number of leaves/shoots) were measured to examine how 'Flame Seedless' grapevines responded to foliar application of monopotassium phosphate (MKP) and leaving 30 bunches per vine.

Data presented in table 1 shows that foliar treatment with MKP at 3g/L and leaving 30 bunches per vine significantly increased shoot length, shoot diameter, and number of leaves/shoots as compared with the other treatments in both seasons. However, in both seasons the lowest values of shoot length, shoot diameter, and number of leaves/**sho**ots were observed in the control. In addition, there was no significant difference between the treatment of leaving 30 bunches/vines and foliar with MKP at g/L + 30 bunches/vine in number of shoot diameter and leaves/shoots.

Table 1. Effect of foliar with monopotassium phosphate and bunches thinning on shoot length, shoot diameter, and number of leaves/shoots of 'Flame Seedless' grapevines.

Treatments		Shoot length (cm)		Shoot diameter (cm)		Number of leaves/ shoot	
		2023	2024	2023	2024	2023	2024
T1	Control (leaving 40 bunches/vine)	124.00 d	132.00 c	0.94 c	0.99 c	17.14 c	17.76 c
T2	Foliar with monopotassium phosphate (MKP) at 3 g/L with leaving 40 bunches /vine	132.33 c	141.33 b	1.04 b	1.09 b	18.66 b	19.33 b
T3	Bunch thinning (leaving 30 bunches /vine)	140.33 b	144.6 ab	1.12 ab	1.15 ab	20.47 a	20.38 ab
T4	Foliar with MKP at 3 g/L + bunch thinning by leaving 30 bunches/vine	149.00 a	150.66 a	1.16 a	1.20 a	21.43 a	21.43 a

Means with the same letters in each season are insignificantly different at $p \leq 0.05$ using Tukey's HSD test.

3.2. Physical attributes of bunch and total yield

Data in Table 2 shows that effect of foliar application of MKP and leaving 30 bunches per vine on cluster weight, length, and width of 'Flame Seedless' grapevines. Foliar treatment with MKP at 3 g/L and leaving 30 bunches per vine significantly increased bunch weight, length, and width as compared with the other treatments in both seasons. However, in two seasons, the lowest values of bunch weight, length, and width were observed in the control. In addition, there was no significant difference between treatments of leaving 30 bunches/vines and foliar with MKP at g/L + 30 bunches/vine in bunch length in both seasons.

Result in Table 2 indicate that yield/feddan did not significantly differ in response to foliar application of MKP and leaving 30 bunches per vine. The highest value of yield/feddan was registered when foliar application of MKP and leaving 30 bunches/vine and foliar with MKP at 3 g/L in both seasons. In contrast, the lowest significant yield/feddan was registered for control in the two seasons. In addition, there was no significant difference between treatments of foliar with MKP at 3 g/L and foliar with MKP at g/L + leaving 30 bunches/vine in yield/feddan in the first season only.

Table 2. Effect of foliar with monopotassium phosphate and bunches thinning on bunch physical attributes and total yield/feddan of 'Flame Seedless' grapevines

Treatments		Bunch weight (g)		Bunch length (cm)		Bunch width (cm)		Yield/feddan (ton)	
		2023	2024	2023	2024	2023	2024	2023	2024
T1	Control (leaving 40 bunches/vine)	399.33 c	390.66 c	21.33 b	21.56 b	13.50 b	13.86 c	11.18 ab	10.93 ab
T2	Foliar with monopotassium phosphate (MKP) at 3g/L with leaving 40 bunches /vine	415.00 c	403.00 c	22.33 b	22.66 b	14.10 a	14.33 c	11.62 a	11.28 a
T3	Bunch thinning (leaving 30 bunches /vine)	526.00 b	516.66 b	24.36 a	24.50 a	14.13 a	15.33 b	11.04 b	10.85 b
T4	Foliar with MKP at 3g/L + bunch thinning by leaving 30 bunches/vine	546.33 a	538.66 a	25.33 a	25.53 a	14.46 a	15.93 a	11.47 ab	11.31 a

Means with the same letters in each season are insignificantly different at $p \leq 0.05$ using Tukey's HSD test.

3.3. Physical attributes of berry

Berry external quality, including 100 berry weight, berry length, berry width, and firmness, is a crucial metric that represents the quality and development of fruit. As shown in table 3, it is obvious that physical properties of berries, including 100-berry weight, berry length, berry width, and berry firmness, were significantly increased by foliar application of MKP and leaving 30 bunches per vine compared to control in both seasons. The berry weight, berry length, berry width, and firmness gradually improved with increasing combinations of application of

MKP and leaving 30 bunches per vine.

Further observing the data, the application of MKP at a rate of 3 g/L and leaving 30 bunches per vine used in this study was the most favorable in increasing 100 berry weight (261.40 and 266.73 g), berry length (18.66 and 19.00 mm), berry width (17.66 and 18.00 mm), and berry firmness (4.20 and 4.54 N) compared to the other treatments, where it gives the highest significant values in both seasons.

Table 3. Effect of foliar with monopotassium phosphate and bunches thinning on berry physical attributes of 'Flame Seedless' grapevines

Treatments		Weight of 100 berry (g)		Berry length (mm)		Berry width (mm)		Berry firmness (N)	
		2023	2024	2023	2024	2023	2024	2023	2024
T1	Control (leaving 40 bunches/vine)	199.66 c	201.33 d	15.66 c	16.66 b	15.33 b	16.00 b	2.33 c	2.79 c
T2	Foliar with monopotassium phosphate (MKP) at 3g/L with leaving 40 bunches /vine	210.66 b	231.66 c	17.33 b	18.33 a	16.33 ab	17.33 a	3.23 b	3.63 b
T3	Bunch thinning (leaving 30 bunches /vine)	251.67 a	249.34 b	18.00 ab	18.66 a	17.00 a	17.66 a	3.65 b	4.04 b
T4	Foliar with MKP at 3g/L + bunch thinning by leaving 30 bunches/vine	261.40 a	266.73 a	18.66 a	19.00 a	17.66 a	18.00 a	4.20 a	4.54 a

Means with the same letters in each season are insignificantly different at $p \leq 0.05$ using Tukey's HSD test.

While the control recorded the lowest weight of 100 berries (199.66 and 201.33 g), berry length (15.66 and 16.66 mm), berry width (15.33 and 16.00 mm), and berry firmness (2.33 and 2.79 N) in 2022 and 2023, respectively. Also, data showed that there were non-significant differences between foliar with MKP at 3 g/L and leaving 30 bunches/vine on berry firmness in the two seasons.

4. Discussion

Our results indicate that foliar application with monopotassium phosphate (MKP) at a rate of 3 g/l and substantial agricultural practices (leaving 30 bunches per vine) in grapevines improved vegetative growth and physical properties of bunches and berries. MKP is a fully water-soluble composite and an excellent source of P and K widely used in horticulture (Kumar et al., 2017; Meng et al., 2017). In the present study, the results clearly demonstrated that fertilization with MKP at a rate of 3 g/l concentration significantly improved vine growth and flower production (El Botaty et al., 2023).

Monopotassium phosphate has the function of a regulator, which can effectively promote the growth and development of root system, accelerate the differentiation of crop flower buds, increase the number of flowers, and make the flower become plump, and the fruit setting rate is significantly improved (Baiea et al., 2015). Several studies have reported a positive effect of MKP fertilization on vine growth and the quality and quantity of bunches and fruit (Aly et al., 2020; Villette et al., 2020) mentioned (K) as a necessary element for 4 vital roles for membrane maintenance and growth, namely cellular membrane transportations and assimilate translocation, enzyme activation, anion neutralization, and osmotic regulation. Thus, foliar sprays of MKP at 1 and 1.5% at different periods had improved bunch weight and yield and physical bunches. Also, Aly et al. (2015) showed that spraying Superior grape with foliar K and B combination recorded the highest yield and the heaviest cluster weight. Aly et al. (2020) applied treatment of potassium phosphate to Crimson seedless grapes and revealed that yield components, and physical bunches had improved. In addition, treatments raised berry weight and firmness. Romero et al. (2020) revealed that preserving grape firmness depends on cell wall genes coding degrading enzymes.

MKP can improve the ability of crops to resist adverse weather conditions such as drought, waterlogging, and freezing; promote the healing of damaged tissue of crops; and resist the infection of pathogens. Spraying MKP during the fruit expansion period can protect and strengthen the fruit, promote fruit expansion, improve fruit quality, increase coloring, and improve the taste (Rui et al., 2012).

Bunch thinning is a common management technique executed by grape growers to control the production amount to be within the limits of the natural load and improve bunch quality (Fawzi and Abd ElMoniem, 2003). The improvement of physical properties of clusters and berries (Table 2 and 3) could be due to the decreasing number of clusters per vine, which allowed the allocation of a large amount of photosynthesis products and reserves of nutrients and water to each of the remaining clusters (Naor and Gal, 2002). Reducing the cluster number per vine without changing the number of leaves or shoots leads to reducing the competition between the clusters on essential materials, which leads to improved physical properties of clusters and berries (Radwan and Masood, 2017). Also, Omar and Aboryia (2020) indicated that all cluster thinning applications increased average cluster weight, berry weight and diameter of Ruby Seedless grapevines.

In addition, thinning of clusters or berries determines the clusters' size, directly promoting their ripening (Belal et al., 2016). Cluster thinning also affects the availability of stored food material required to grow developing clusters after the fruit thinning. A rising number of clusters on the vine could reduce berry dimensions (Somkuwar and Ramteke, 2010).

Achieving vine balance is critical to the productivity and sustainability of a vineyard. It is defined as the balance between reproductive and vegetative growth and is a useful tool in understanding overall vine health and vigor levels, optimum production capacity, and canopy and fruit exposure (Poni et al. 1994), or any combination of these factors. Clusters can be removed from the vines at any time between fruit set and near véraison, but it is better to do it earlier to get effective results under the conditions of the present study. Cluster thinning by removing some bunches significantly increased cluster and berry weight and improved the berry quality, according to Fazekas et al. (2012), Gatti et al. (2012), Belal et al. (2022) and Elaidy et al. (2025).

5. Conclusion

From the previous results, it can be concluded that spraying MKP at 3 g/L until runoff at three different times: 2 weeks after the beginning of vegetative growth, when shoot length reached about 25–30 cm, after berry set, and at the beginning of berry coloring (véraison stage), and leaving 30 bunches per vine after the fruit set improvement of vegetative growth, bunch weight, bunch length, width, berry weight, firmness, length, and width.

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