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(Original Article)

Impact of Various Potassium Fertilizers on Yield and Berries Characteristics of Red Roomy Grape Cultivar

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Abstract

This research was conducted on the grapevine "Red Roomy" cultivar seasonally in 2020 and 2021 to study the effect of both 100% potassium RDK as a soil application, which was the recommended dose, and 50% potassium RDK plus one of the foliar fertilizer sources, such as Hanfu humate (4000 ppm), Delta Sol standard (4000 ppm), nano-K_2SO_4 (750 ppm), potassium silicate (4000 ppm), and Novastroka (4000 ppm), on Red Roomy grapevine vegetative growth, fruit production, and berry characteristics. Data revealed the possibility of using foliar fertilizer sources to partially replace mineral potassium fertilizer. The data showed that the maximum values from vegetative growth traits, yield components, and juice chemical properties were measured on vines treated with 50% RDK + 4000 ppm Novastroka, followed by vines treated with 50% RDK + 4000 ppm Delta Sol standard. Moreover, the minimal amounts of these characteristics were scored on vines treated with 50% RDK + 4000 ppm Hanfu humate. It could be concluded that applying 50% RDK + 4000 ppm Novastroka to vines three times annually was necessary to ensure the optimal traits for vegetative growth, improving standards of fruit quality, harvest, and the nutrition condition of a vine, in addition to reducing the production costs and environmental pollution resulting from the increased use of mineral fertilizers on Red Roomy grapevines under Assiut conditions in Egypt.

Keywords: *Humate, Delta Sol, Nano, Silicate, Novastroka.*

Introduction

Among the most considerable Fruits produced worldwide is the grapevine (*Vitis vinifera* L.), not only for fresh consumption but also for raisins and the wine industry. It takes up more land worldwide than any other fruit crop and produces nearly half of all consumed worldwide. Grapes are the third most popular fruit grown in Egypt, behind mangoes and citrus. Particularly on the reclaimed lands, the area under cultivation has expanded quickly. It extended to approximately 80004 hectares, of which about 73380 are productive and produce a combined 1446761894 kilograms annually.

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Numerous initiatives have been attempted to increase grapevine productivity, including addressing production issues and enhancing horticulture methods. The Assiut region's Red Roomy cultivar has some challenges, most notably declining production and a lack of berry coloring, which have an adverse effect on marketing to domestic or international markets, Abd Al Sanad-Aya (2022). Fertilizer is one of several effective strategies for raising output. One of the key strategies for improving fruit yield and quality is mineral nutrition (Tagliavini and Marangoni, 2002). Unfortunately, the efficiency of chemical fertilizer use is low, leading to higher production costs and environmental contamination (Wilson *et al*., 2008). As a result, it can be beneficial to apply and evaluate different fertilization techniques to provide essential components for vine growth and productivity while maintaining a healthy soil structure and a clean environment (Miransari, 2011; Doaa *et al.,* 2019). The study by Mpelasoka *et al.* (2003) illustrated that potassium fertilizer is considered a technique of agricultural treatment that can immediately affect the growth and standards of grapes. As the most prevalent cation in grape berries at all stages of growth, is a crucial nutrient for grapevines (Rogiers *et al*., 2006; Martins *et al*., 2012). One of the main problems that farmers deal with is the high cost of fertilizers. The overuse of chemical fertilizers has led to major issues, such as soil salinity and underground water pollution, and has made mineral potassium fertilizer highly expensive in Egypt. Researchers have therefore focused on finding partial replacements for mineral sources of fertilizer that are safe for people, animals, and the environment (Belal *et al.,* 2017; Abd El-Rahman and Al-Sharnouby, 2021).

Additionally, it has been estimated that between 50 and 90 percent of the potassium in applied fertilizers is lost to the environment and isn't taken up by plants, which results in significant monetary losses. Solanki *et al.* (2015). Foliar application is just a supplemental measure to guarantee that plants receive an adequate amount of nutrients, according to Inglese *et al*. (2002). On crops with large leaf surfaces, foliar fertilization does not replace soil fertilization, but it may increase the efficiency and uptake of the nutrients supplied to the soil (Kannan, 2010).

The goal of this study was to provide more information about the potential of, decreasing the quantities of mineral potassium fertilizers by employing the foliar spray with different sources of it as a partial substitute for vegetative growth, fruit production, and berry characteristics of the Red Roomy grapevine cultivar in Assiut Region, Egypt.

Materials and Methods

This study was conducted throughout two succeeding growing seasons in 2020 and 2021 on the "Red Roomy" cultivar of grapevine grown in the experimental orchard of the Pomology Department, Faculty of Agriculture, Assiut University, Egypt, where the soil is clay. At the start of this trial, the vines were planted 2 x 2.5 m apart and were 12 years old. Twenty-four standardized grapevines from the cultivar were selected and devoted to achieving this study.

The customary schedule was followed for all routine agro-technical procedures for grapevine plantations recommended by the Ministry of Agriculture.

Using a typical head training system, "Red Roomy" cultivars were pruned with 15 fruiting spurs each with three buds and five replacement spurs each with two buds. 55 buds were therefore still present on each vine as a whole. Six treatments were applied to the vines, each of which was repeated four times.

Every vine has undergone the subsequent treatments:

- 100% soil application from the recommended dose of potassium RDK 125g K2O/vine (T1).
- 50 % soil application RDK + spray with 4000 ppm Hanfu humate (T2).
- 50 % soil application RDK + spray with 4000 ppm Delta Sol standard (T3).
- 50 % soil application RDK + spray with 750 ppm Nano-K2SO4 (T4).
- 50 % soil application RDK + spray with 4000 ppm Potassium Silicate (T5).
- 50 % soil application RDK + spray with 4000 ppm Novastroka (T6).

Potassium sulfate, which included 48 percent potassium oxide, was added as a soil treatment at rates of 100% (125 g/vine) and 50% (75 g/vine) in three similar potions, however, Hanfu humate, Delta Sol standard, potassium silicate, Novastroka, and Nano-K were used as a foliar application. Hanfu humate was potassium humate (12% K2O+67% humic acid), Delta Sol standard (12/0/45) was NPK (12% N+40% potassium nitrate+5% potassium acetate), potassium silicate was (10% K2O +25% silicon oxide), Novastroka was (37% potassium citrate+13% magnesium), and nano-potassium sulfate fertilizer was produced by Nano Lab, Faculty of Science, Assiut University. Three stages saw the use of these treatments: the start of vegetative development, the fruit-set stage, and the version stage. The producers' recommendations and earlier studies were taken into consideration while determining the dosage of each spraying chemical.

In each vine throughout the two seasons under consideration, the following characteristics were measured:

Vegetative growth Parameters

1- Leaf area

Twenty mature leaves from the main shoots opposing the basal clusters were measured for length and width, and the average leaf area (cm^2) was computed. Ahmed and Morsy (1999) stated that the following equation was used to calculate the leaf area (cm2).

$$\text{Leaf area } (cm^2) = 0.36\ (L \times W) + 15.38$$

L= leaf length, **W**= leaf width, then the average leaf area was registered.

2- Total chlorophyll

Using the Minolta non-destructive chlorophyll meter SPAD 502, leaf samples from the fifth and sixth apical leaves on the main shoot/vine were collected during the second week of June.

3- Leaf potassium

From leaves opposite basal clusters, samples of twenty leaves per copy were taken. To determine the macro-elements, leaves were ground after being dried at 70°C to a consistent weight. Each sample's 0.2 g of crude dried powder was wet digested with a solution of concentrated sulfuric acid and perchloric acid before being boiled to create a clear solution. After digestion, the solution was diluted with distilled water and put into a 50-ml flask for analysis. Potassium content (%) was calorimetrically measured according to Wilde et al. (1985) using the Flame photometry instrument.

4- The weight of wood pruned after one year

was measured directly following winter pruning and was represented as g/vine.

Yield components

1-Before bloom, three flower clusters on each labeled branch/vine were placed in white paper bags with holes to estimate the proportion of berries that would be set. Berry set was then determined as follows:

$$\text{Berry set \%} = \frac{\text{No. of berries/cluster}}{\text{Total no. of flowers/cluster}} \times 100$$

2-The clusters were picked during harvest (the first week of September), and the following yield components were noted:

- Yield weight (kg/vine) = No. of clusters/vines × average of cluster weight.

- Cluster weight (g.) was measured using an analytical balance in grams.

Berry chemical properties

Three clusters were randomly chosen from each vine, to analyze the chemical composition of the clusters and berries.

1- TSS %: In juice was determined by using a hand refractometer.

2- Titratable acidity %: as tartaric acid conforming with A.O.A.C. (2000).

3- Reducing sugars (%): conforming with Lane and Eynon procedure outlined in A.O.A.C. (2000).

4- Total anthocyanin (mg/100g). According to Onayemi et al. (2006).

Statistical analysis

A randomized complete block design (RCBD) was used to set up the experiment, with three replications of each treatment and one vine in each replication. Conforming with Gomez & Gomez (1984) and Snedecor & Cochran (1989), all the collected data were tabulated and evaluated, and the L.S.D. test at a 5% level of probability was used to identify significant differences between the treatment means Steel and Torrie (1980).

Results

1-Impact of various sources of potassium on some vegetative growth traits

The result presented in Table 1 reported the effect of potassium soil application (100% RDK) and partially 50% of it, plus five foliar fertilizer sources, namely Hanfu humate, Delta Sol standard, Nano-K, Potassium Silicate, and Novastroka, on the weight of wood pruned, leaf area, total chlorophyll, and potassium percentages in leaves of Red Roomy grapevines during 2020 and 2021 seasons. The data in the abovementioned table revealed that vegetative growth traits varied significantly according to different studied treatments, and the data showed the same trend during successive seasons.

Table 1. Impact of various potassium fertilizers on vegetative growth traits of Red Roomy grapevines through 2020 and 2021 seasons

Characteristics	Pruning wood weight (g)		Leaf area (cm^2)		Total chlorophyll (%)		K (%) in Leave	
Treatments	2020	2021	2020	2021	2020	2021	2020	2021
T_1	650.91	737.50	109.10	101.15	45.50	43.27	0.43	0.45
T_2	512.53	623.25	99.25	92.11	41.40	39.88	0.35	0.33
T_3	796.15	831.40	121.81	113.52	49.30	46.43	0.49	0.63
T_4	537.50	616.67	100.42	91.81	41.42	41.63	0.37	0.34
T_5	666.72	758.40	104.77	105.18	45.16	43.13	0.43	0.44
T_6	811.60	875.00	127.89	118.56	47.80	44.85	0.52	0.60
LSD 5%	49.61	53.62	7.85	7.23	1.92	2.11	0.03	0.05

T1:100% RDK (check treatment)
T2:50 % RDK + 4000 ppm Hanfu humate.
T3:50 % RDK + 4000 ppm Delta Sol standard
T4:50 % RDK + 750 ppm Nano-K2SO4
T5:50 % RDK + 4000 ppm Potassium Silicate
T6:50 % RDK + 4000 ppm Novastroka

In both successive seasons, the maximum values of pruning wood weight were recorded on vines that were treated with both T6 (811.60, 875.00 g) and T3 (796.15, 831.40g), respectively and there were insignificant differences between them while there were significant variations with the other treatments.

In the same way as the effect of T6 and T3 on the leaf area, they gave the highest values (127.89, 118.56 cm3) and (121.81, 113.52 cm3) in both seasons, respectively, without significant variation between them but with significant variations with the other treatments.

The percentage of total chlorophyll reached its maximum in T3 (49.30, 46.43%) and T6 (47.80, 44.85%) in both seasons, respectively, with insignificant differences between both of them, but with the other treatments, there were significant differences.

In the first season, the highest value of k% in leaves was in T6 (0.52%), with significant differences from the other treatments, and the lowest value was found in T2 (0.35%). In the second season, the highest values of K% were found in both T3 (0.63%) and T6 (0.60%), with insignificant differences between both but significant differences from the other, and the lowest values were found in T2(0.33%) and T4(0.34%) with trivial variations between them.

Therefore, the data in two successive seasons demonstrated that the best treatments that gave a positive effect on vegetative growth traits were 50% soil application RDK + spray with 4000 ppm Novastroka (T6) and 50% soil application RDK + spray with 4000 ppm Delta Sol standard (T3) compared with the other treatments.

2-Impact of various sources of potassium on yield characteristics

Data in Table 2 illustrated the effect of potassium fertilization sources on berry set (%), cluster weight (g), and yield (kg/vine) during two study seasons. The berry set reached the highest percentage in both T3 (17.91, 19.69%) and T6 (18.50, 19.47%), respectively, in the two seasons, and there was an insignificant difference between them, but there were significant differences between them from the other treatments. It was noticed that cluster weight followed the same direction as the effect of potassium fertilization sources during the two studied seasons. While the maximum values of cluster weight were in T3(416.52, 389.9g) and T6 (442.17, 380.70g), respectively.

In the first season, the highest value of yield was recorded in T6 (14.58), and there was a significant difference with the other treatments. In the second season, T3(13.65kg) increased to reach the same level as T6 (13.48 kg) and had the highest value too, without significant variation between them but with significant variation with the other treatments.

As a result, the data from two successive growing seasons showed that, when compared to the other treatments, 50% soil application RDK + spray with 4000 ppm Novastroka (T6) and 50% soil application RDK + spray with 4000 ppm Delta Sol standard (T3) gave the best results on yield components.

Table 2. Impact of various potassium fertilizers on yield characteristics of Red Roomy grapevines through 2020 and 2021 seasons

Characteristics / Treatments	Berry set (%)		Cluster weight (g)		Yield (kg/vine)	
	2020	2021	2020	2021	2020	2021
T_1	16.66	17.65	378.50	338.85	13.10	12.13
T_2	15.72	16.52	336.67	336.17	11.46	11.83
T_3	17.91	19.69	416.52	389.9	13.73	13.65
T_4	15.41	16.03	350.33	325.80	12.00	11.41
T_5	16.55	17.95	395.30	343.25	13.35	12.10
T_6	18.50	19.47	442.17	380.70	14.58	13.48
LSD 5%	1.22	1.30	33.85	28.15	1.11	1.15

T1:100% RDK (check treatment) T2:50 % RDK + 4000 ppm Hanfu humate.
T3:50 % RDK + 4000 ppm Delta Sol standard T4:50 % RDK + 750 ppm Nano-K2SO4
T5:50 % RDK + 4000 ppm Potassium Silicate T6:50 % RDK + 4000 ppm Novastroka

3- Impact of various sources of potassium on juice chemical properties

Data in Table 3 showed that these Juice chemical properties varied significantly according to different studied treatments, and the data showed a similar trend during the two studied seasons.

The maximum values of TSS were recorded on both T3 (17.00, 19.38%) and T6 (16.91, 18.82%), respectively, in two successive seasons without significant differences between them but with significant differences for the other treatments. Whereas T3 increased a trivial amount compared to T6.

In both seasons, the lowest value of acidity % was found in T6 (0.27, 0.32%), respectively, followed by T3 (0.28, 0.33%), respectively, with significant differences, and the other treatments came after them with significant differences.

Data in Table 3 proved that T3 and T6 in both seasons had the highest amount of reducing sugar % and anthocyanin, with significant differences with the other treatments. Whereas T3 recorded (15.70, 16.68%) and T6 recorded (15.53, and 16.64%) from reducing sugar, respectively, with insignificant differences between them. In the same way, T3 gave (3.01, 2.95 mg/100g) and T6 (2.98, 2.99 mg/100g) from anthocyanin, respectively, with trivial differences between them.

Table 3. Impact of various potassium fertilizers on chemical characteristics of juice of Red Roomy grapevines through 2020 and 2021 seasons

Characteristics	TSS %		Titratable acidity %		Reducing sugar %		Anthocyanin (mg/100gm)	
Treatments	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
T_1	15.48	16.60	0.34	0.41	14.56	14.65	2.17	2.19
T_2	15.33	16.73	0.34	0.41	14.35	14.83	2.19	2.13
T_3	17.00	19.38	0.28	0.33	15.70	16.68	3.01	2.95
T_4	16.29	17.13	0.31	0.36	14.96	15.17	2.51	2.60
T_5	16.33	17.50	0.32	0.36	14.90	15.40	2.65	2.71
T_6	16.91	18.82	0.27	0.32	15.53	16.64	2.98	2.99
LSD 5%	0.56	0.67	0.01	0.01	0.48	0.61	0.15	0.13

T1:100% RDK (check treatment) T2:50 % RDK + 4000 ppm Hanfu humate.
T3:50 % RDK + 4000 ppm Delta Sol standard T4:50 % RDK + 750 ppm Nano-K2SO4
T5:50 % RDK + 4000 ppm Potassium Silicat T6:50 % RDK + 4000 ppm Novastroka

Discussion

The benefits of potassium in plant nutrition were widely explored by several researchers. For all phases of protein synthesis and all aspects of plant growth, it is regarded as a crucial mineral nutrient Arquero *et al.* (2006) and plays a significant part in the transfer of metabolites, protein synthesis, stomatal function, internal pH stabilization, enzyme activation, and photosynthesis Abd El-Rahman and Hoda (2016). Furthermore, higher potassium content in the leaf may result in more chloroplasts per cell, increased cells per leaf, and then, increased leaf area Taiz and Zeiger, (2002). Hassan (2002) reported that K percentages in leaf blades and petioles increased with potassium spraying in both seasons. Additionally, it was noted by Ahmad (2000), Poni *et al.* (2003), and Licina *et al.* (2010) that adding potassium to the soil increased the K concentration in the blades of grapevines' main and lateral shoots. Such an increment in yield/vine to use these treatments because of increasing cluster weight as a result of improving the growth and vigor of vines. Additionally, potassium regulates a number of enzyme activities in plants by altering the pace of photosynthesis and increasing the rate of translocation from leaves through the phloem to storage tissue, which enhances fruit output and quality (Saykhul *et al.,* 2013).

Contrarily, Knoll *et al*. (2006) showed that the tested foliar fertilizers had no impact on leaf potassium levels in two seasons. The impact of fertilizing with potassium on 'Riesling', 'Chardonnay', and 'Cabernet Sauvignon' fruiting grapevines cultivated under controlled circumstances in a greenhouse was investigated, and the higher K fertilization had no impact on fruit yield (Morris and Cawthon, 1982).

Zaree *et al*. (2015), Mohyeldein *et al*. (2019), and Dakrony and Mona (2020) all proved that potassium fertilization's favorable effects on grapevine yield components. They concluded that applying various potassium fertilization methods had a favorable impact on cluster characteristics as well as yield in various grape cultivars.

Potassium might not have a direct effect on the yield and its constituents, such as the weight of 100 berries and the number of bunches of the grape (Boonterm *et al*., 2013; Schreiner *et al*., 2013). Additionally, it is prevalent in plants at every level, from the individual cellular through xylem and phloem transport. Additionally, it enhances fruit size, juice content, color, and flavor to raise the quality of the fruit (Tiwari, 2005).

Mohsen (2011) on "Crimson seedless", grapevines and Thakur *et al*. (2008) on "Perlette" grapevines both found similar results. Higher cell division and photosynthetic activities may be to blame for the increase in fruit weight and length (Doaa *et al*., 2019; Kumaran *et al*., 2019). According to some authors (Tiwari, 2005; Ashraf *et al*., 2010; Zhang *et al*., 2010; Amiri and Fallahi, 2007; and Upadhyay *et al*., 2019), potassium spraying increased the chlorophyll content and promoted an increase in the photosynthetic products, leading to improved fruit quality by enhancing fruit size, juice contents, color, and juice flavor.

Potassium may facilitate the transfer of newly generated photosynthesis by increasing sugar content, which would benefit the mobilization of metabolites that have been stored (Evans and Sorger, 1966). Additionally, it plays a crucial role in fruit growth, increasing fruit size, soluble solids, and color. At all phases of its growth, the grape fruit contains the highest concentration of K^+ (Tiwari, 2005; Ashraf *et al*., 2010; Martins *et al*., 2012; Wadee, 2022).

Also, it could be seen from the data that total soluble solids were equivalent to reducing sugars and reversed current with acidity; these results were reconciled with those obtained by Martin *et al*. (2004) and Abd-El-Razek *et al*. (2011).

The sugar-to-acid ratio of the berries is improved by potassium’s role in the conversion and transportation of sugars through the phloem. Delgado *et al*. (2004) demonstrated that by promoting vine photosynthesis, providing K^+ to vines improved the color and polyphenol content of berries. It may be the cause of the rise in SSC of fruits was the hydrolysis of starch into simple sugars and the function of potassium in the transfer of sugar from leaves to fruits (Kumaran *et al*., 2019).

Contrarily, in the majority of V. vinifera grapevine varieties, soluble solids are typically correlated with the anthocyanin level (Martnez-Gil *et al*., 2018).

Le *et al*. (2022) also claimed that the overall amounts of phenols, proanthocyanidins, and anthocyanins in the Beibinghong berries were adversely correlated with their titratable acidity. Contrarily, anthocyanins' contents were not affected by K+. The contents of anthocyanins, on the other hand, were unaffected by K+. They went on to say that fertilizer applications may not be as effective at controlling berry color as the ripening process. Abd-El-Razek *et al*. (2011).

Conclusion

According to the results of this study, it was found that spraying 50% RDK + 4000 ppm Novastroka to vines three times a year (at the start of vegetative growth, after the fruit set stage, and at veraison) was essential for ensuring the best vegetative growth traits, improving vine nutrition status, increasing yield components, and improving cluster quality attributes, as well as lowering production costs and providing the best production of Red Roomy grapevines under Assiut conditions, Egypt.

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تأثير الأسمدة البوتاسية المختلفة على المحصول وخصائص العناقيد لصنف عنب رومى الأحمر

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الملخص

أجريت هذه الدراسة خلال موسمين 2021، 2020 على كرمات العنب الرومي الاحمر التي تبلغ من العمر 12 سنة المنزرعة في المزرعة البحثية بكلية الزراعة - جامعه اسيوط. بهدف دراسة تأثير التسميد الورقي بالبوتاسيوم كبديل جزئي عن التسميد الارضي. على النمو الخضري والثمري وخصائص الثمار في العنب الرومي الاحمر.

أظهرت النتائج امكانية استبدال جزء من السماد المعدني البوتاسي 50% ليحل محله أحد الاسمدة الورقية وهي كالتالي: هانفوهيومات، دلتاسول ستاندرد، نانو بوتاسيوم، سيليكات بوتاسيوم ونوفاستروكا على النمو الخضري وخصائص الثمار والمحصول في العنب الرومي الاحمر.

ادى احلال 50% من السماد المعدني بكلا من 4000 جزء في المليون من النوفا ستروكا و4000 جزء في المليون من الدلتاسول ستاندرد الى زيادة معنوية في خصائص النمو الخضري والثمري بالمقارنة بمعامله المقارنة (100% تسميد معدني).

أدت معاملة احلال 50% من التسميد المعدني بكلا من 4000 جزء في المليون من هانفوهيومات ومن 750 جزء في المليون من النانو بوتاسيوم الى نقص معنوي في خصائص النمو الخضري والثمري بالمقارنة بمعامله الكنترول 100%.

لا توجد فروق معنوية بين معامله احلال 50 % من التسميد المعدني بسيليكات البوتاسيوم 4000 جزء في المليون ومعامله المقارنة 100 % في خصائص النمو الخضري والثمري.

أعلى قيمه قيست لتحسين خصائص النمو الخضري والثمري والمحصول في معامله احلال 50 % معدني +الرش بسماد نوفاستروكا بتركيز4000 جزء في المليون بالمقارنة بمعامله الكنترول 100%.

اقل قيمه قيست من تلك الخصائص الخضرية والثمرية باستخدام احلال 50% معدني + الرش ب هانفوهيومات بتركيز 4000 جزء في المليون بالمقارنة بالكنترول 100%.

يمكن التوصية بإحلال 4000 جزء في المليون من سماد النوفاستروكا بدلا من 50% من التسميد البوتاسي الارضي وذلك رشاً ثلاث مرات عند بداية النمو واثناء التزهير وعند مرحله الفيرايزون حيث يؤدي ذلك الى تحسين النمو الخضري والحالة الغذائية للكرمات والتي تعطي بدورها محصولا عاليا ذو خصائص ثمريه جيدة مع تقليل تكلفة السماد ومشاكل تلوث البيئة الناشئ عن زيادة الاسمدة المعدنية.