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Research Article

Response of Grape Plants (*Vitis vinifera L.*) to Fertigation with Different Potassium Fertilizers under Egyptian Sandy Soil

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Abstract

A field experiment was carried out in El-Tahreer sandy soil (Agrofarms El-Fateh farm) to investigate the biological response of grape plants (*Vitis vinifera* L.) (var. Superior) to fertigation with the combination ratios of the three potassium fertilizers, i.e. KNO3, K2SO4 and KCl. Each experiment included 12 combinations treatments of K-KCl/K-KNO3/K-K2SO4 as following: 0/100/0, 25/75/0, 50/50/0, 75/25/0 100/0/0, 0/0/100, 25/0/75, 50/0/50 75/0/25, 0/25/75, 0/50/50 and 0/75/25 relative to 100 that equals the total K requirements during the growth season. In general some nutrients content (as %) (N, K, P, Ca, Mg and Cl) were slightly affected by fertigation with different potassium fertilizers in the petioles and leaves of grape plants. It could be concluded that grape plants, showed a positive response to the fertigation with two treatments of the potassium fertilizers combination ratios K-KCl/K-KNO3/K2SO4 (50/50/0) and (50/0/50). Also they can improve nutrients content in grape plant tissues, grape plant's resistance to diseases, grape plant's growth and the total and exportable clusters fresh yield.

Keywords: Potassium Fertilizers Sources; Fertigation; Grape; Plant Growth; Disease; Fruit Yield and Quality; Sandy Soil

Introduction

Grape (*Vitis vinifera*) is one of the oldest cultivated plants (recorded in ancient Egypt in 4000 B.C.). Potassium is important for grape in which it improves the main physiological stages at which it needed for bud differentiation stage, bud fixing stage, cane maturity, formation of fruitful buds, translocation of sugars to berries, provides an attractive look and a long shelf life of grapes [1]. Potassium have many roles or functions and is important to profitable crop production: stimulates early growth; increases the protein production; improves the efficiency of the water use; promotes the photosynthesis and thus leads to the formation of carbohydrates, oils, fats and proteins; essential for the formation and translocation of sugars in plants; vital for stand persistence, longevity and winter hardiness and improves resistance to diseases and insects [2]. The most common fertilizer sources of potassium in crop production are K_2SO_4, KNO_3, KCl and KH_2PO_4. Injection of potassium through micro-irrigation systems has been very successful. In addition, the fertilizer should be evaluated in part based on its cost per unit of nutrient, so that KCl has the lowest cost as compared with KNO_3 or K_2SO_4 [3]. Fertilizer water solubility and its compatibility to mix with other fertilizers must be considered when fertigation system is used. The solubility of the different potassium sources could be arranged in the following order: $KCl>KNO_3>K_2SO_4$ where water solubility of K_2SO_4, KNO_3 and KCl are 12, 13.3 and 34.7 g/100 ml of water at 25 oC, respectively [4].

Despite the high demands of fruit trees for potassium, the agricultural specialists have not made the necessary considerations for this important fact and the consequent negligence in the use of potassium fertilizers along with continues cultivation practices which lead to potassium depletion [5].

Therefore, The objective of this study was to investigate the response of grape plants as a fruit crop grown on sandy soil to fertigation with some potassium fertilizers (KCl, KNO_3 and K_2SO_4) each alone or in combinations on nutrients content, fruit yield and quality, their effect on soil and also the response to diseases.

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Materials and Methods

A field experiment was conducted on sandy soil (Typic Torriorthent) to evaluate the response of grape plants (*Vitis vinifera* L.) (var. Superior) to fertigation with some potassium fertilizers, i.e. KNO_3, K_2SO_4 and KCl each alone or in combinations. This study was carried out during the production season on three years old vigorous fruitful superior grape vines grown in a private vine yard (Agro-farms) at south of El-Tahreer. The experiment area divided into twelve treatments. The factorial experiment was designed as a split plot each treatment consisted of three replicates, one vine constituted the experiment unit. The chosen vines were nearly similar in growth and vigor planted in sandy soil at 1.5 x 4 meters. All treatments were irrigated by drip system (25mm PE header line, 16mm lateral pipes and 2.3 litre per hour discharge), two lines of irrigation were used, using fertigation system. Each treatment separated using a fertigation unit.

The application of organic fertilizers (60 m^3 cattle manure) and inorganic fertilizers as kg/fed (300 super-phosphate 15% P_2O_5, 100 ammonium sulfate 20.6% N, 100 potassium sulfate 48% K_2O, 50 sulfur and 500 gypsum in addition to 50 zinc sulfate and 40 manganese sulfate) which were broadcasted and incorporated in soil.

The experimental treatments

Fertigation was applied at the following twelve combination ratios of potassium chloride (63% K_2O) K-KCl, potassium nitrate (13% N and 46% K_2O) K-KNO_3 and potassium sulfate (50% K_2O) K-K_2SO_4: (100 / 0 / 0), (75 / 25 / 0), (50 / 50 / 0), (25 / 75 / 0), (0 / 100 / 0), (0 / 75 / 25), (0 / 50 / 50), (0 / 25 / 75), (0 / 0 / 100), (25 / 0 / 75), (50 / 0 / 50) and (75 / 0 / 25) relative to 100 that equal to the total K requirement during growth stage (160 unit for grape). The maximum Cl concentration in the treatment of 100 / 0 / 0 (K-KCl / K-KNO_3 / K-K_2SO_4) was about 9.5 meq/ l or 337.25 mg/l (114 mg/l supplied from KCl + 222 mg/l supplied from irrigation water).

Samples and analysis

Soil sampling

Soil samples were collected from the depth 0-60 cm before the beginning of the experiments and subjected to standard methods of physical and chemical analysis [6], Jackson [7]. Data in Table 1 show some physical and chemical properties of the soil sample representing the selected area of experiment.

Physical properties	Value		
Texture	Sand % 93	Silt % 4	Clay % 3
Saturation Percentage	24.2		
Infiltration rate (mm/hr)	70.2		
Chemical properties	Value		
pH	7.24		
EC dS/m	0.31		
% Calcium carbonate	1.72		
% Organic matter	0.23		
Water soluble cations (meq / L)			
Ca^{++}	1.52		
Mg^{++}	0.74		
Na^{+}	0.38		
K^{+}	0.36		
Water soluble anions (meq / L)			
CO_3^{--}	Not detected		
HCO_3^{-}	0.09		
SO_4^{--}	1.12		
Cl^{-}	1.78		
Available elements (ppm)			
Ca	1852		
Mg	457		
K	253		
P	18.4		
Fe	8.98		
Cu	1.84		
Zn	8.66		
Mn	0.75		

Table 1: Some characteristics of grape experimental site.

Plant sampling and analytical techniques

Leaves and petioles samples of grape plants (*Vitis viniferaL*. var. Superior) were collected during blooming and fruiting stages. Plant samples were dried at 70°C. The dried plant samples were milled and kept for analysis.

N, P, K, Ca, Mg, and Cl content in the collected samples were determined according to [8], Page *et al*. [9] and Jackson [7].

Sampling and analytical quality tests

Vegetative growth

Vines of each treatment were pruned by pinching main shoots, removing some vegetative shoots, removing some lateral branches and defoliation. Weight of three year old pruning wood (kg) was recorded at the pruning time the last weeks of December. It was taken two times (at the beginning and the end of the exp.).

Yield attributes

At harvest time (15-16% TSS, 0.6-0.7 acidity and 24 – 26 TSS/Acid ratio, first week of June). Clusters for each treatment were weighted (kg) and also average cluster weight (gm).

Physical characteristics

The berry firmness using penetrometer and then calculated as g/cm^2 as described; also berry size (cm) and berry shuttering (%) were determined.

$$\% \text{ Shuttering} = \frac{\text{Weight of shuttered berries}}{\text{Initial weight of the grape cluster}} \times 100$$

Chemical characteristics

Fruit samples were quality analyzed for certain parameters. Total soluble solids (TSS) in fruit juice were determined using a hand refractometer as weight/volume (%). L-Ascorbic acid representing vitamin C content was determined as mg ascorbic acid/100 gm fresh fruit juice [10]. Total titratable acidity was measured by titrating the fruit juice sample against 0.1 N NaOH solution using Phth indicator [10]. The results were expressed as mg of citric acid/100g fruit juice. Also, fruit yield was recorded for each treatment just after harvesting. Also TSS/Acidity ratio was determined by calculation.

Sampling and microbiological analysis

Each treatment in the grape experiment was evaluated. Levels of incidence and severity of Botrytis bunch rot were determined by evaluating five clusters per vine. Disease incidence was expressed as a percentage of clusters with any visual appearance of disease while disease severity was determined by visually estimating the percent rot per cluster [11].

When the clusters reached the optimum maturity for harvest, fruits were picked in the early morning. In the laboratory these clusters were stored, lined with perforated polyethylene bags, five replicates were placed at 5oC and 85 – 90% in cold storage.

Stored fruits were examined after one week, decay percentage was determined. This value was calculated by weight as follows:

$$\% \text{ Decay} = \frac{\text{Decayed berries}}{\text{Initial weight of the grape cluster}} \times 100$$

Samples of grape berries, exhibiting rot symptoms were collected from stored clusters to isolate the causal organisms associated with rot symptoms, small potions were cut from the rotted berries and transferred to ready plates of potatoes dextrose agar (PDA) medium and incubated at 30oC for 7 days. The fungal isolates were then purified by using single spore or hyphal tip technique with aid of microscope at x100 to x400 and propitiate taxonomic keys [12] the isolated fungi were identified.

Statistical analysis

Data of the experiment were statistically subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS software package [13]. Means were separated by least significant difference (LSD) test at 5% probability level.

Results

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO$_3$/K K$_2$SO$_4$) on some nutrients content in the leaves and petioles of grape plants after blooming stage:

Data in Table 2 showed the effect of fertigation with KCl, KNO$_3$ and K$_2$SO$_4$ each alone or in different combination ratios on N, P, K, Ca, Mg and Cl contents in the petioles of grape plants after blooming stage. Regarding the influence of KCl (100/0/0), KNO$_3$ (0/100/0), K$_2$SO$_4$ (0/0/100), data indicated that there was no significant difference for P content. On the other hand, K and Cl contents (as%) markedly decreased from 3.00 for KCl to 2.80 and2.40 for K$_2$SO$_4$ and KNO$_3$and from 0.85 for KCl to 0.56 and0.29 for K$_2$SO$_4$and KNO$_3$, respectively.

Treatments	Petioles nutrient contents (%)					
KCl/KNO$_3$/K$_2$SO$_4$	N	P	K	Ca	Mg	Cl
100/0/0	1.18	0.26	3.00	2.30	0.53	0.85
75/25/0	1.22	0.24	2.60	2.24	0.32	0.67
50/50/0	1.24	0.22	2.50	2.30	0.41	0.54
25/75/0	1.22	0.23	2.50	2.35	0.35	0.43
0/100/0	1.35	0.25	2.40	2.42	0.42	0.29
0/75/25	1.26	0.28	2.40	2.46	0.40	0.32
0/50/50	1.23	0.26	2.00	2.41	0.36	0.37
0/25/75	1.20	0.23	2.60	2.30	0.31	0.32
0/0/100	1.24	0.24	2.80	2.10	0.38	0.56
25/0/75	1.24	0.24	2.40	2.15	0.33	0.54
50/0/50	1.21	0.23	2.50	2.03	0.39	0.61
75/0/25	1.20	0.21	2.40	2.07	0.41	0.72
LSD 0.05	*0.06*	*0.03*	*0.29*	*0.10*	*0.11*	*0.18*

Table 2: Effect of fertigation with differentK-fertilizers combination ratios on some nutrients content in the petioles of grape plants.

In contrast N, Ca and Mg contents in the petioles of grape plants increased from 1.18 for KCl to 1.24 and 1.35 for K$_2$SO$_4$and KNO$_3$, from 2.10 for K_2SO_4 to 2.30 and2.42 for KCland KNO_3 and also from 0.38 for K_2SO_4 to 0.42 and 0.53 for $KNO_3$and KCl, respectively.

Regarding the effects of the tested combination treatments on some nutrients content in grape plant's tested tissues, data in Table 2 revealed that the highest values for nutrients content in the petioles of grape plants were obtained for the combination treatments of 0/100/0 for N, 0/75/25 for P and Ca, 100/0/0 for K, Mg and Cl. Meanwhile the lowest values were obtained for the combination treatments of 0/25/75 for N and Mg, 75/0/25 for N and P, 0/50/50 for K, 50/0/50 for Ca and 0/100/0 for Cl.

Data in Table 3 showed the effect of fertigation with KCl, KNO_3 and K_2SO_4 individually or in different combination ratios on N, P, K, Ca, Mg and Cl contents in the leaves of grape plants after blooming stage. Concerning the influence of KCl (100/0/0), KNO3 (0/100/0), K_2SO_4 (0/0/100) each was used alone as a source of K, data indicated that Mg content was not significantly affected by the tested sources of K. On the other hand, N and P markedly increased from 1.18 for K_2SO_4 to 1.20 for KCl to 1.35 for KNO_3, and from 0.25 for KCl to 0.33 for KNO_3 to 0.35 for K_2SO_4, respectively. In contrast K, Ca and Cl contents in the leaves of grape plants decreased from 2.80 for KCl to 2.20 for KNO_3 to 2.00 for K_2SO_4, from 2.01 for KNO_3 to 1.89 for KCl to 1.53 for K_2SO_4 and also from 0.78 for KCl to 0.45 for K_2SO_4 to 0.29 for KNO_3, respectively.

Treatments	Leaves nutrient contents (%)					
$KCl/KNO_3/K_2SO_4$	N	P	K	Ca	Mg	Cl
100/0/0	1.20	0.25	2.80	1.89	0.37	0.78
75/25/0	1.24	0.33	2.40	1.98	0.37	0.62
50/50/0	1.24	0.31	2.40	1.86	0.36	0.58
25/75/0	1.24	0.29	2.30	1.89	0.37	0.61
0/100/0	1.35	0.33	2.20	2.01	0.36	0.29
0/75/25	1.28	0.26	2.20	1.86	0.36	0.38
0/50/50	1.26	0.31	2.15	1.74	0.31	0.26
0/25/75	1.26	0.28	2.10	1.80	0.37	0.39
0/0/100	1.18	0.35	2.00	1.53	0.35	0.45
25/0/75	1.18	0.23	2.10	1.59	0.34	0.47
50/0/50	1.16	0.29	2.30	1.64	0.39	0.53
75/0/25	1.16	0.31	2.30	1.68	0.39	0.67
LSD 0.05	*0.18*	*0.09*	*0.32*	*0.13*	*0.06*	*0.15*

Table 3: Effect of fertigation with different K-fertilizers combination ratios on some nutrients content in the leaves of grape plants.

Regarding the effects of the tested combination treatments, data in Table 3 showed that the highest values for some nutrients contents in the leaves of grape plants were obtained for the combination treatments of 0/100/0 for N and Ca, 0/0/100 for P, 50/0/50 and 75/0/25 for Mg and 100/0/0 for K and Cl. Meanwhile, the lowest values were obtained for 50/0/50 and 75/0/25 for N, 25/0/75 for P, 0/0/100 for K and Ca, 0/50/50 for Mg, and 0/100/0 for Cl.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on some nutrients content in the leaves and petioles of grape plants after fruiting stage:

Data in Table 4 shows the effect of fertigation with KCl, KNO_3 and K_2SO_4 individually or in different combination ratios on N, P, K, Ca, Mg and Cl contents (as %) in the petioles of grape plants after the fruiting stage. Concerning the influence of KCl (100/0/0), KNO_3 (0/100/0), K_2SO_4 (0/0/100) each was used alone as a source of K, data indicated that P and Mg content were not significantly affected by the tested sources of K.

Treatments	Petioles nutrient contents (%)					
$KCl/KNO_3/K_2SO_4$	N	P	K	Ca	Mg	Cl
100/0/0	0.96	0.24	2.80	2.10	0.67	0.88
75/25/0	0.98	0.24	2.60	2.05	0.69	0.62
50/50/0	0.98	0.25	2.50	2.01	0.59	0.52
25/75/0	0.98	0.22	2.30	1.93	0.55	0.44
0/100/0	1.38	0.23	2.10	1.89	0.62	0.34
0/75/25	1.08	0.23	2.30	1.84	0.79	0.38
0/50/50	0.92	0.25	2.40	1.93	0.72	0.45
0/25/75	0.92	0.23	2.50	1.84	0.61	0.47
0/0/100	0.88	0.23	2.00	1.18	0.64	0.48
25/0/75	0.88	0.22	2.30	1.85	0.62	0.58
50/0/50	0.88	0.23	2.40	1.80	0.66	0.57
75/0/25	0.82	0.25	2.50	1.83	0.64	0.61
LSD 0.05	*0.25*	*0.02*	*0.29*	*0.21*	*0.22*	*0.14*

Table 4: Effect of fertigation with different K-fertilizers combination ratios on some nutrients content in the petioles of grape plants.

On the other hand, N content markedly increased from 0.88 for K_2SO_4 to 0.96 for KCl and 1.38 for KNO_3. In contrast, K, Ca and Cl contents in the petioles of grape plants decreased from 2.80 for KCl to 2.10 for $KNO_3$and 2.00 for K_2SO_4, from 2.10 for KCl to 1.89 for KNO_3 and 1.18 for K_2SO_4 and from 0.88 for KCl to 0.48 for $K_2SO_4$and 0.34 for KNO_3, respectively.

Regarding the effects of the tested combination treatments, data in Table 4 indicated that the highest values for some nutrients contents in the leaves of grape plants were obtained for the combination treatments of 0/100/0 for N, 50/50/0, 0/50/50 and 75/0/25 for P, 0/75/25 for Mg, 100/0/0 for K, Ca and Cl. Meanwhile the lowest values were obtained for 75/0/25 for N, 25/75/0 for P and Mg, 25/0/75 for P, 0/0/100 for Ca and 0/100/0 for K and Cl.

Data in Table 5 showed the effect of fertigation with different K-fertilizers KCl, KNO_3 and K_2SO_4 each alone or in different combination ratios on N, P, K, Ca, Mg and Cl contents in the leaves of grape plants after the fruiting stage.

Treatments	Leaves nutrient contents (%)					
$KCl/KNO_3/K_2SO_4$	N	P	K	Ca	Mg	Cl
100/0/0	0.94	0.22	3.00	0.97	0.58	0.65
75/25/0	0.94	0.21	2.80	0.86	0.46	0.52
50/50/0	0.93	0.20	2.50	0.89	0.65	0.46
25/75/0	0.90	0.23	2.40	0.89	0.51	0.40
0/100/0	1.26	0.24	2.20	1.16	0.53	0.29
0/75/25	0.96	0.24	2.20	1.06	0.65	0.41
0/50/50	0.95	0.28	2.50	0.94	0.67	0.37
0/25/75	0.94	0.22	2.20	0.91	0.65	0.39
0/0/100	0.88	0.23	2.10	0.86	0.67	0.48
25/0/75	0.88	0.21	2.30	0.80	0.69	0.53
50/0/50	0.88	0.21	2.30	0.72	0.66	0.59
75/0/25	0.84	0.24	2.30	0.91	0.56	0.62
LSD 0.05	*0.21*	*0.07*	*0.09*	*0.10*	*0.22*	*0.11*

Table 5: Effect of fertigation with different K-fertilizers combination ratios on some nutrients content in the leaves of grape plants.

Concerning the influence of KCl (100/0/0), KNO_3 (0/100/0), K_2SO_4 (0/0/100) each was used alone as a source of K, data indicated that P content was not significantly affected by the tested sources of K.

On the other hand, N, Mg and Ca markedly increased from 0.88 for K_2SO_4 to 0.94 for KCl and 1.26 for KNO_3, from 0.53 for KNO_3 to 0.58 for KCl and 0.67 for K_2SO_4, and from 0.86 for K_2SO_4 to 0.97 for KCl and 1.16 for KNO_3, respectively. In contrast, K and Cl contents in the leaves of grape plants decreased from 3.00 for KCl to 2.20 for $KNO_3$and 2.10 for K_2SO_4, and from 0.65 for KCl to 0.48 for $K_2SO_4$and 0.29 for KNO_3, respectively.

Regarding the effects of the tested combination treatments, data in Table 5 showed the highest values for studied nutrients contents in the leaves of grape plants were obtained for the combination treatments of 0/100/0 for N and Ca, 0/50/50 for P, 25/0/75 for Mg and 100/0/0 for K and Cl. Meanwhile, the lowest values were obtained for 75/0/25 for N, 50/50/0 for P, 0/0/100 for K, 50/0/50 for Ca, 75/25/0 for Mg and 0/100/0 for Cl.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on vegetative growth attribute of grape plants:

Regarding the weight of one year old pruning woods, data in table 6 showed that the highest values were obtained with KCl/KNO_3 and KCl/K_2SO_4 combinations.

Treatments $KCl/KNO_3/K_2SO_4$	Pruning woods (kg/tree)	
	Before treatments 22/12/2005	After treatments 18/12/2006
100/0/0	4.41	4.70
75/25/0	4.27	4.72
50/50/0	3.42	4.84
25/75/0	3.98	4.42
0/100/0	3.12	3.42
0/75/25	2.38	3.98
0/50/50	3.87	4.33
0/25/75	3.02	4.53
0/0/100	3.86	4.21
25/0/75	2.55	3.45
50/0/50	2.43	4.35
75/0/25	2.33	4.87
LSD 0.05	*0.77*	*0.49*

Table 6: Effect of fertigation with different K-fertilizers combination ratios on berry weight of pruning woods as vegetative growth attribute of Superior seedless grape.

However, KNO_3 at 100 ratio and KCl/K_2SO_4 at 25/75 ratio produced significantly less weight of pruning woods than the other combination. All used treatments generally increased weight of pruning woods after K-fertilizers combination ratio application.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on some crop yield parameters of grape:

Data in Table 7 show the effect of K-combination ratios on yield attributes i.e. berry diameter (mm), number of clusters per tree, cluster weight (g) and average total yield in kg/feddan.

Treatments $KCl/KNO_3/K_2S_04$	Grape yield parameters			Total yield ton/fed
	cm/ Berry	Cluster/ Tree	g/ Cluster	
100/0/0	21.9	30.0	435.8	9.15
75/25/0	21.7	27.0	439.6	8.30
50/50/0	22.7	38.0	470.0	12.50
25/75/0	22.1	30.0	456.0	9.57
0/100/0	22.0	27.0	436.0	8.24
0/75/25	21.4	31.0	419.8	9.11
0/50/50	22.5	31.0	418.0	9.07
0/25/75	22.3	30.0	412.2	8.66
0/0/100	22.4	24.0	454.2	7.63
25/0/75	21.6	27.0	440.8	8.33
50/0/50	22.6	34.0	462.2	11.00
75/0/25	22.5	32.0	431.2	9.66
LSD 0.05	*1.3*	*12.0*	*54.7*	*1.34*

Table 7: Effect of fertigation with different K-fertilizers combination ratios on some crop yield parameters of grape.

Regarding the influence of KCl (100/0/0), KNO_3 (0/100/0) and K_2SO_4 (0/0/100) each was used alone as a source of K on some crop yield parameters, data in Table 7 indicated that there were no significant differences between the three mentioned sources on berries diameter, clusters per tree and cluster weight. On the other hand, there was a significant increase in the average total yield (ton/fed) from 7.63 for K_2SO_4 to 8.24 for $KNO_3$and 9.15 for KCl. Regarding the effects of the tested combination treatments on some crop yield parameters, data revealed that the highest values obtained for the combination treatments 50/50/0 for berries diameter, cluster per tree, cluster weight and the average total yield.

Data showed that the average of total yield/fed and also average of cluster weights were the highest significantly affected with K-combinations 50/50/0 and 50/0/50. However, no significant differences were found between the other K-combination ratios.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on some physical properties of superior seedless grape:

Data in Table 8 show the change in some physical properties of Superior seedless grapes as affected by fertigation with K-combination ratios, firmness (g/cm^3) and shuttering (%). Regarding the influence of KCl (100/0/0), KNO3 (0/100/0) and K_2SO_4 (0/0/100) each was used alone as a source of K on some physical properties, data in Table 8 indicated that shuttering (%) significantly increase from 0.13 for KCl to 1.49 for KNO_3 to 2.05 for K2SO4. On the other hand firmness (g/cm^3) decreased from 4.69 for K_2SO_4 to 4.48 for KCl to 3.82 for KNO_3. Regarding the effects of the tested combination treatments on some physical properties, data revealed that the highest values obtained for the combination treatments 25/0/75 for shuttering and firmness. Meanwhile the lowest value obtained for the combination treatment 100/0/0 for shuttering and 0/100/0 for firmness.

Treatments KCl/KNO_3/K_2SO_4	Physical properties	
	Shuttering (%)	Firmness (g/cm^2)
100/0/0	0.13	4.48
75/25/0	0.59	4.52
50/50/0	0.68	5.08
25/75/0	0.86	5.15
0/100/0	0.96	3.82
0/75/25	0.89	4.49
0/50/50	0.48	4.62
0/25/75	1.49	4.76
0/0/100	0.29	4.69
25/0/75	2.05	5.35
50/0/50	0.23	4.80
75/0/25	0.88	4.99
LSD 0.05	*0.55*	*0.40*

Table 8: Effect of fertigation with different K-fertilizers combination ratios on some physical properties of Superior seedless grape.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on some chemical properties of superior seedless grape.

Data in table 9 show the effect of K- fertilizers combination ratios fertigation treatments on some chemical properties of Superior seedless grapes.

Treatments KCl/KNO_3/ K_2SO_4	Chemical properties			
	TSS %	Acidity %	TSS/ Acidity	Vitamin C mg/100g
100/0/0	15.58	1.10	14.16	16.7
75/25/0	15.36	1.05	14.63	12.5
50/50/0	15.80	1.30	12.15	14.6
25/75/0	15.36	1.15	13.36	15.0
0/100/0	14.16	1.10	12.87	10.4
0/75/25	14.26	1.25	11.41	14.6
0/50/50	14.69	1.20	12.24	12.5
0/25/75	14.84	1.20	12.37	16.7
0/0/100	14.24	1.30	10.95	12.5
25/0/75	15.18	1.00	15.18	14.6
50/0/50	15.02	1.15	13.06	12.5
75/0/25	15.36	1.00	15.36	14.6
LSD 0.05	*0.55*	*0.10*	*1.43*	*1.88*

Table 9: Effect of fertigation with different K-fertilizers combination ratios on some chemical properties of superior seedless grape.

Total soluble solids (TSS) contents show some significant increases especially with KCl combinations ratios. However, no significant differences were noticed between different KCl combination ratios.

Some trends of results were obtained with titratable acidity. Generally, it could be noticed that titratable acidity in grape fertigated with KCl-combination ratios at maturation ranged from 1.0 to 1.3%.

The ratio between TSS and acidity was parallel to its components. Also the KCl-combination ratios increased TSS/acid ratio than the other treatments.

Effect of fertigation with K-fertilizers combination ratios (K-KCl/K-KNO_3/K-K_2SO_4) on grape bunch rot diseases:

Levels of incidence and severity of grape bunch rot diseases were determined by evaluating 50 clusters per K-combination treatment. Disease incidence was expressed as a percentage of clusters with any visual appearance of disease; while disease severity was determined by visually estimating the percent rot per cluster.

Data in Table10 cleared that, in K-combination trials the disease incidence ranged from 6.8 to 9.0% for KCl/KNO_3ratios and from 6.1 to 8.7% for KCl/K_2SO_4 ratios, but KNO_3/K_2SO_4 combination ratios had a greater disease incidence ranged from 7.1 to 9.3% than other

K-combination ratios, but differences were not statistically significant Table 10. KCl/KNO_3 (75/25) had the highest disease severity (3.7%) and KCl/KNO_3 (25/75) the lowest (2.2%), but they were not significantly different.

Treatments KCl/KNO_3/K_2SO_4	Incidence (%)(*)	Severity (%)(*)
100/0/0	9.00	2.4
75/25/0	6.00	3.7
50/50/0	7.10	3.5
25/75/0	6.80	2.2
0/100/0	8.90	3.5
0/75/25	8.30	3.6
0/50/50	7.10	3.8
0/25/75	9.30	2.9
0/0/100	9.40	3.1
25/0/75	8.70	2.5
50/0/50	6.70	2.3
75/0/25	6.10	2.5
LSD 0.05	*2.54*	*0.7*

Table 10: Effect of fertigation with different K-combination ratios on incidence and severity of bunch rot of superior grape.

(*) Incidence (%) and severity (%) were determined by evaluating five clusters per vine in all treatments visually.

Observed berries that showed typical symptoms of *B. cinerea, Alternaria* sp. or *Aspergillus* sp. As it is shown in (Figure 1), after 7 days of storage the number of fruit rot caused by *Aspergillus* or *Alternaria* sp or gray mold caused by *Botrytis cinerea* were nearly similar in all K-combination ratios trials, no significant differences were found between all combination ratios.

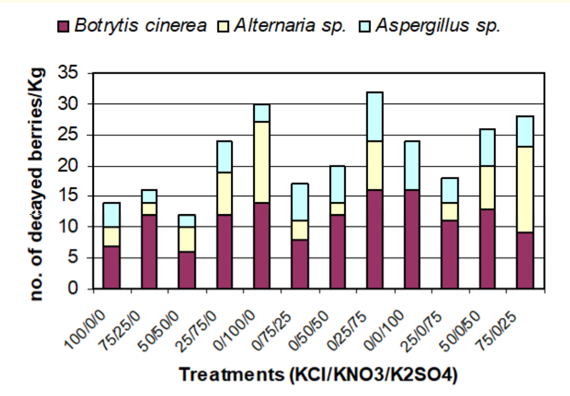

Figure 1: Post-harvest decay of superior seedless table grape stored for 7 days ys at 5oC.

Discussion

In general, the concentrations of the tested nutrients contents in the petioles and leaves of grape trees superior var. were in the adequate range of the elements recommended by [14].

The reduction in N concentrations in grape leaves and petioles by increasing KCl application comparing with that for KNO_3 application may be due to the antagonistic effect between NO_3- and Cl- uptake. Chloride ion can replace NO_3 ions in chemical function. The observed reduction in Mg content in petioles and leaves of grape trees as affected by KCl treatments are in agreement with that obtained by Marco., *et al.* [15] they found that leaf Mg content was significantly lower in the KCl treatment.

It could be also concluded that the difference in the associated anions with the source of K-fertilizers may slightly affect the nutrient composition of the final crop yield but was not significantly affecting the economical yield of grape plants in well drained sandy soil either from quantity or quality point of view. In addition to lowering the cost of crop fertilization making the fertilization process more easily by using K-fertilizer in chloride form comparing with the other source of K-fertilizers.

Also results obtained in case of grape, and total soluble solids (TSS) contents show some significant increases with the use of K-combination ratios especially with KCl-combinations. However, no significant differences were noticed between these K-fertilizers combination ratios.

The titratable acidity data trend was in agreement with Chapagain and Wiesman [16] who found that KCl improved fruit qualities. The observed insignificant effects of the different K-fertilizers each alone or in combination, on the studied parameters of crop yield are in agreement with that observed on plant growth Ibrahim., *et al.* [17].

A slight increase in crop yield parameters of grape trees was observed by Ganeshamurthy., *et al.* [1], they found that the large potential for plant Cl uptake where from KCl, the most common K fertilizer which may positively affected cold hardiness, grape fruit yield and quality. They reported that the mobile Cl anion may influence the uptake and efficient use of plant nutrients as a consequence of interactions with uptake of cations or anions.

Fageria., *et al.* [18] suggested that the chloride salts have some positive effects on soil borne plant pathogens. This may allow the plant to absorb large concentrations of Cl in the absence of a metabolically active cation like NH_4.

Arabi and Jawhar [19] found that both NaCl and KCl reduced common root rot in barley. Other groups similarly found that NaCl or KCl did not differ in their effects and reported that 50 Kg KCl/ha reduced common root rot of barley in 2 of 6 experiments. Study on the role of chloride salts on *Rhizoctonia* root rot caused by *Rhizoctoniasolan*i found that NaCl, KCl, $CaCl_2$ and $MgCl_2$ all equally suppressed disease and promoted growth.

In some soil, chloride salts inhibits conversion of NH_4 to NO_3 presumably due to its inhibitory effect on species of nitrosomonas bacteria. This probably explains our finding in which cleared that most KCl combination ratios treatments reduce significantly the soil fungal population, also frequencies of fungal genera isolated before application with the same treatments were different from those isolated after treatments. In addition, soil treated with chloride salts show an immediate release of soluble manganese ions. Manganese has been implicated in disease suppression probably through its effect on increasing host resistance.

Similar reports of KCl suppressing disease while reducing osmotic potentials have been made on pearl millet affected by downy mildew, wheat affected by take-all disease, and asparagus affected by *Fusarium* [20]. In our results KCl-combinations treatments qualitatively changed the soil fungal population, where *Trichoderma* sp increased in soil after treatments because *Trichoderma* sp are well known antagonistic fungi, their presence in soil could contribute to a beneficial effect in health of plants. This result supported by the findings of Elmer [21] who found that changes in osmotic potential affect the water cycling of plants and the exudation of carbon substrates. These substrates serve as a food base for microbes that live on and around the root. The possible role that beneficial Pseudomonas species might play in disease suppression on chloride treated wheat plants was recognized studies KCl on celery confirmed that root exudates were being altered. When asparagus plants were treated with KCl, an increase in the beneficial Pseudomonas species was noted. Thus treating plant with chloride salts causes a root mediated effect on the microbial community [20].

Conclusion

Regarding the effect of fertigation with KCl, KNO_3 and K_2SO_4 each alone or in different combination ratios on grape plants, it could be concluded that:

Nutrients content in grape plant tissues, average of cluster weights and plant's resistance to diseases, growth and the total and exportable fresh yield showed a positive response to the fertigation with two treatments of the potassium fertilizers combination ratios K-KCl/K-KNO_3/K_2SO_4 (50/50/0) and (50/0/50).

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