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Ameliorative Effect of Yeast and Gamma Irradiated Licorice Extracts on Growth, Yield, Fruit Quality and Nutrient Content of Red Globe Grapevine

Mohamed F. Ahmed#, Noha E. Eliwa, Hossam M. Ismail
Natural Products Department, National Center for Radiation Research and Technology, Egyptian Atomic Energy Authority, Cairo, Egypt.

ONE of the most important problems facing red globe grapevine is limited vegetative growth which promotes cluster sunburn. The present study was conducted during two seasons of 2021 and 2022 on five– year-old red globe grapevine to evaluate the possible improvement of growth, sunburn, yield, fruit quality and nutrient content by applying yeast and gamma-irradiated licorice extracts. Yeast extract soil was added to the vines at concentrations of 0 and 4 g L-1, while licorice (*Glycyrrhiza glabra*) extract, whether irradiated or not was sprayed or soil added at three levels (0, 4 and 8 g L-1). The results indicated that the application of licorice extract alone was superior to yeast extract. The higher level of licorice, whether soil added or foliar, yielded the highest values compared to the lower level. Combined application of yeast and licorice extract, whether irradiated or not, gave a superior response compared to sole application. Additionally, the addition of licorice extract alone or combined with yeast extract significantly reduced the number of clusters affected by sunburn. In conclusion, gamma irradiation of licorice enhanced its positive effect on most of the measured properties of red globe grapevine, especially when yeast extract was added in combination.

Keywords: Gamma irradiation, Licorice, Red globe, Yeast, Yield.

Introduction

Grapes (*Vitis vinifera* L.) are considered one of the main fruit crops in the world trade. The world's production of grapes reached 75.1 million metric tons, thus, it occupies the third or fourth place in terms of total productivity. At the level of agriculture in Egypt, grapes are the fourth main crop. The annual production is approximately 1.7 million metric tons which makes Egypt rank fourteenth in the world. The increase in production is due to the success of many introduced rootstocks and varieties (FAO, 2017).

Red Globe grapevine has a major advantage of high productivity; however, the optimal production of yield encounters many serious challenges. One of these challenges is diminished vegetative growth which allows the exposure of large areas of clusters to direct sun radiation, in addition to high berry sensitivity to sunlight which increases the risk of sunburn (Shaker, 2015). Sunburn damage not only deteriorates yield but also reduces cluster quality, making them unsuitable for marketing, as the consumption of grapes depends mainly on their external appearance (Ozer et al., 2012).

Foliar fertilization is a successful scientific method for treating nutrient deficiency. Yeast, a biofertilizer, is one of the richest sources of protein, and it contains essential amino acids such as lysine and tryptophan among others. It contains many mineral elements, such as calcium, cobalt and iron, and it also contains vitamin B groups such as B1, B2, B6, and B12. Yeast extract is a valuable source of vital ingredients, especially cytokinins which act as a readily available growth supplement for plants that ultimately improve plant production (Amer, 2004). Licorice (*Glycyrrhiza glabra*) extract has attracted attention for its possible use as a plant bio stimulant; it comprises many biological compounds, such as

#Corresponding author email: ms_omarmohamed@yahoo.com
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glycerrhzel and glescerzin and other compounds with similar effects, such as growth regulators, to improve vegetative and flowering characteristics. Foliar application of licorice extract on potato plants significantly increased plant length and dry weight and gave a higher marketable yield compared to the control (Matar et al., 2012).

The application of ionizing radiation to degrade this natural bioactive agent and then use it as a growth–promoting substance is an emerging technology to exploit the full genetic potential of crops in terms of growth, yield, and quality (Naeem et al., 2012). Gamma irradiation is one of the methods used to modify the physicochemical properties and biological activities of compounds. Gamma irradiation of *Glycyrrhiza glabra* root at doses of 20 and 25 kGy increased antibacterial activity, phenolic contents and DPPH scavenging activity (Khattak & Simpson, 2010).

Many cultural practices are needed for table grape production to increase consumer preference and improve the final quality of berries. Therefore, the aim of the present study is to evaluate the physiologic effect of yeast and gamma- irradiated licorice extracts on the growth, sunburn, yield, fruit quality and nutrient content of Red Globe grapevine.

Materials and Methods

The current study was performed with five-year-old Red Globe grapevine, *Vitis vinifera* L. table grape cultivar, in a commercial orchard in the Cairo-Alexandria Desert Road, Egypt (30°13′31.4″N30°39′09″E) during two growing seasons (2021 and 2022). Vines were planted in a sandy soil at 3 x 3 m (row x vine) under a drip irrigation system and trellised by a Spanish parron system. The vines were pruned during the second week of January. Canopy division has typically been accomplished by training vines to four permanent arms with 16 fruiting spurs x 5 buds each with a total vine load of 80 buds. Vines were adjusted to 40 clusters per vine and all clusters were tipped to approximately 12 cm in length after fruit set. One hundred twenty six vines were designed as a completely randomized block design (14 treatment x 3 replicates x 3 vines for each replicate). The experimental vines were selected on the basis of healthy, uniform size nearly similar in growth vigor and estimated crop load and subjected to the common horticultural practices that are already applied in the vineyard. The physical and chemical properties of the soil are presented in Table 1.

TABLE 1. Some soil physical and chemical properties

Season	2021	2022
Soil texture	sandy	Sandy
Sand (%)	83.5	83.0
Clay (%)	4.0	4.5
Silt (%)	12.5	12.5
pH	8.01	8.0
EC(ds cm^{-1})	1.99	1.81
Cl-	8.1	8.3
$SO4^{--}$	9.94	10.54
Ca^{++}	8.3	8.5
Mg^{++}	1.6	2.1
Na^{+}	9.2	9.3
K^{+}	1.43	1.6
$HCO3^{-}$	2.49	2.6 6

Yeast and licorice root extract

Active dry yeast powder (200 g) was dissolved in one liter of distilled water, followed by the addition of sugar at a ratio of 1:1 and incubation overnight for the activation and reproduction of yeast (El-Tohamy et al., 2008). The yeast extract was filtered by Whatman filter paper No. 1, and the final volume was increased to liter and then diluted to the needed volume of the used concentration.

The extraction of licorice root was performed according to Abd El-Azim et al. (2017) with some modifications. For irradiated licorice extract, each 50 g of licorice root powder was mixed with 100 ml of distilled water to make a paste and then gamma irradiated at a dose of 10 kGy (dose rate of 0. 86, 0.85 and 0.84 KGy h^{-1} for April, May and June 2021 and 0.76, 0.75 and 0.74 KGy h^{-1} for April, May and June 2022, respectively). Irradiation was performed at the National Center for Radiation Research and Technology using Gamma Cell (^{60}Co). After irradiation, the volume was increased to 1 litre by adding distilled water and left to complete 24 hours from the beginning of mixing. For non-irradiated licorice extract, each 50 g of licorice root powder was mixed with 100 ml distilled water to make a paste and left for a time equivalent to the time of irradiation. Then, the volume was increased to 1 liter by adding distilled water and left to complete 24 hours from the beginning of mixing. After that, the licorice drenched either irradiated or not irradiated was filtered using Whatman filter paper No. 1 and the final volume was completed to liter and then diluted to the needed volume of the used concentration. Table 2 illustrates the chemical profiles of the yeast and licorice extracts.

Treatments

Yeast extract (Y) was soil added (S) alone or combined with licorice at 0 and 4 g L-1, while licorice (*Glycyrrhiza glabra*) extract (L) whether irradiated (γ) or not, was sprayed (F) or soil added (S) alone or combined with yeast at three levels (0, 4 and 8 g L-1). The extracts were applied to red globe grapevine on three successive dates as follows: 15th April, 15th May and 15th June in both seasons.

Measurements

Vegetative measurements including shoot length, diameter, leaf area as well as total leaf chlorophyll content were estimated. For shoot length and diameter (cm), 4 shoots per vine were chosen and labeled at the beginning of season and were measured at the end of September each season. Leaf area (cm^2) was measured for ten leaves randomly collected in mid-May from each treatment using a leaf area meter, Model CI 203, U.S.A. The total leaf chlorophyll content was measured in mature 6th and 7th apical leaves by means of a Minolta chlorophyll meter model soil plant analysis development 502 (SPAD 502) (Wood, 1993).

Thirty-six bunches from each treatment were harvested at random on the last week of July in both seasons, and then transported to the laboratory to measure the physical and chemical properties of red globe grapevine. Four bunches per vine were employed to determine the average bunch weight (g). Forty-eight grape berries from each replicate were selected randomly for calculation of average berry volume (cm^3) and average berry weight (g). The number of bunches with sunburn was counted at harvest time. Yield per vine (kg) was determined as the number of bunches (40) per vine multiplied in bunch weight (g) divided by 1000 and yield increasing % was calculated using the following equation according to Al-Saif et al. (2023):

$$\text{Yield increasing (\%)} = \frac{\text{Yield (treatment)} - \text{yield (control)}}{\text{yield (control)}} \times 100$$

Acidity %, expressed as tartaric acid (%), was determined by titrating 5 ml juice from each sample against NaOH (0.1N) using phenolphthalein as indicator, TSS% was determined with hand refractometer and TSS/acid ratio were calculated. All abovementioned parameters were determined in berry juice after being extracted from 48 berries representing each replicate according to AOAC (2006). The total anthocyanin content in grape berry rinds (mg per 100 g fresh weight) was colorimetrically determined (OD 535 nm) according to the method described by Connor et al. (2002).

N, P, and K concentrations were determined in oven- dried petiole samples of the 5th and 6th apical leaves. Nitrogen was determined by the modified micro-Kejldahl method as described by Wild et al. (1985). Phosphorus was estimated by the Olsen photometric method while potassium was determined using a flame photometer (Chapman & Pratt, 1962).

Statistical analysis

This experiment was set as a randomized complete block design; the statistical analysis of the present data was carried out according to Snedecor & Cochran (1982). The individual comparisons between the obtained values were carried out using M-STAT computer software program at the 5% level.

TABLE 2. Chemical profile of yeast and licorice root (*Glycyrrhiza glabra*) extracts

Compounds	Yeast extract	Non-irradiated licorice extract	Irradiated licorice extract
Total phenols %	0.172	14.7	23.2
Total flavonoids %	0.036	11.1	15.7
Amino acid %	28	5.6	9.3
N %	7.1	1.3	2.7
K %	0.7	0.85	1.89
P %	0.5	0.8	2.5
Fe ppm	55	36	50
Zn ppm	62	50	63
Mn ppm	1.5	5	7

Results and Discussion

Vegetative growth parameters of red globe grapevine

The data in Table 3 revealed that all single application treatments significantly increased shoot length with the highest increment with LS 8. For combined addition, all treatments enhanced shoot length with significant superiority for YS 4 + γ LS 8 followed by YS 4 + LS 8. There was no significant difference between the irradiated and non-irradiated comparable groups. For shoot diameter, all single treatments had no significant effect in either season compared to the control. Among non-irradiated combined treatments, soil yeast with the highest level of licorice whether soil added or foliar increased shoot diameter significantly compared to the control. For the irradiated combined treatments, YS 4 + LS 4, LS 8 or LF 8 significantly increased shoot diameter. No significant difference between irradiated and non-irradiated comparables was detected except with YS 4 + LF 8. All sole applications of licorice had a significant positive effect on leaf area. Additionally, all combined treatments significantly enhanced the grape leaf area with superiority to YS + LS 8 and YS + γ LS 8. Again, insignificant difference between irradiated and non-irradiated comparables could be noticed. Regarding leaf total chlorophyll, all single and combined treatments significantly increased its content with preference to LS 8 either alone or in combination with yeast and irradiated or non-irradiated comparables. The difference between the irradiated and non-irradiated comparables was insignificant.

TABLE 3. Effect of yeast and gamma-irradiated licorice extracts on some vegetative parameters and total chlorophyll of red globe grapevine

Treatments	Shoot length (cm)		Shoot diameter (cm)		Leaf area (cm^2)		Total chlorophyll (mg per 100 g F.W.)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	118.7 g	126.7 h	0.92 c	0.91 c	124.3 h	126.7 f	35.33 h	36.00 i
YS (4g L-1)	136.0 f	133.0 g	0.94 c	0.92 c	128.1 gh	127.3 f	37.00 g	36.33 i
LS (4 g L-1)	152.0 e	146.3 f	0.94 c	0.93 c	135.0 ef	134.0 e	38.00 f	37.00 h
LS (8 g L-1)	167.0 bc	171.7 cd	0.97 c	0.98 bc	140.9 de	147.7 d	39.00 e	39.33 g
LF (4 g L-1)	153.7 e	165.0 e	0.95 c	0.96 c	132.3 fg	136.7 e	42.00 d	42.33 f
LF (8 g L-1)	156.7 de	170.7 cd	0.96 c	0.97 c	139.7 de	140.7 e	42.33 d	43.33 e
YS (4 g L-1) + LS (4 g L-1)	167.7 bc	173.3 bcd	0.98 c	1.03 bc	145.3 cd	150.0 cd	42.67 cd	43.33 e
YS (4 g L-1) + LS (8 g L-1)	175.7 a	180.0 a	1.10 ab	1.20 a	153.7 ab	160.7 a	43.00 bcd	43.43 de
YS (4 g L-1.) + LF (4 g L-1)	165.3 c	169.0 de	0.99 c	1.03 bc	145.3 cd	155.0 abc	43.67 abc	44.00 cd
YS (4 g L-1) + LF (8 g L-1)	168.0 bc	174.7 bc	1.00 bc	1.10 ab	151.3 abc	158.0 ab	44.00 ab	44.67 b
YS (4 g L-1) + γ LS (4 g L-1)	173.7 ab	172.7 cd	1.03 b	1.10 ab	149.3 bc	152.0 bcd	43.00 bcd	43.67 de
YS (4 g L-1) + γ LS (8 g L-1)	178.7 a	182.0 a	1.17 a	1.20 a	155.3 ab	157.3 ab	43.67 abc	44.33bc
YS (4 g L-1) + γ LF (4 g L-1)	162.7 cd	169.3 cde	0.99 c	1.02 bc	151.0 abc	152.3 bcd	44.00 ab	44.4 bc
YS (4 g L-1) + γ LF (8 g L-1)	167.3 bc	178.3 ab	1.13 a	1.09 ab	156.0 a	158.7 ab	44.67 a	45.00 a

Y; yeast, L; licorice, S; soil addition, F; foliar spray, γ; gamma-irradiated
* Means followed by the same letter/s are not significant at the 5% level.

the obtained results regarding the enhancement effect of yeast extract on the growth parameters of red globe grapevine were also reported for summer royal grape (Abdulkadhim & Hadi, 2019) and bitter almond (Al-Douri & Basheer, 2021). Vegetative growth enhancement might be due to the dry yeast extract nutrient content of proteins, nutrients, vitamins, growth factors and free amino acids that enhanced the endogenous phytohormones including auxins, gibberellins and cytokinins thus promoting plant growth, inhibiting chlorophyll degradation, improving photosynthesis process and stimulating protein and DNA synthesis (Shalaby & El-Nady, 2008; Aly et al., 2019). Similarly, yeast extract contains bio regulators such as adenine and betaines that increase photosynthetic pigments via modulation of the balance between the processes of photosynthesis and photorespiration (Olaiya, 2010).

The enhancing effect of licorice extract was consistent with the results obtained by Alsalhy & Aljabary (2020) on cv. Halawany grape where spraying licorice root extract had a significant influence on the leaf area and the leaf chlorophyll content. Additionally, strawberries sprayed with licorice extract showed a significant increase in leaf area compared with the control (Hussein & Al-Doori, 2021). The improved vegetative growth could be attributed to the presence of multiple compounds such as phenolic compounds, triterpenes, saponins, amino acids, polysaccharides, vitamins and growth stimulating phytohormones that increased apical meristem tissue activity through increased cell division and elongation resulting in enhanced plant growth (Zadeh, 2013).

Concerning vegetative growth parameters, the obtained data revealed that soil addition of yeast and high licorice extract level was superior to soil addition of yeast and foliar spraying of licorice extract at both level and to soil addition of low level of licorice extract. This result was consistent with those reported by El-Morsy et al. (2017a), on Red Globe where the highest values of leaf area, shoot length and diameter were obtained with soil addition of licorice extract and yeast 20 mg L^{-1}, followed by 15 mg L^{-1}, then the combined foliar spraying treatments 20 and 15 g L^{-1}, respectively.

Fruit quality and yield parameters of red globe grapevine

The data in Table 4 show the effect of yeast and gamma irradiated licorice extract application on the number of sun-burned bunches, berry volume and weight, bunch weight, yield per vine as well as yield increasing %. Sole application of the high level of licorice extract whether soil added or foliar significantly decreased the number of sun-burned bunches. All combination treatments reduced the number of sun-burned bunches significantly as compared to the control with superior effects with YS 4 + γ LS 8. There was no significant difference between different combination treatments. The berry volume and weight as well as bunch weight, yield per vine and yield increasing % followed a similar trend. All single and combined treatments significantly increased the abovementioned parameters with a preference of licorice above yeast, foliar application over soil addition and high concentration over the low one. The highest values were recorded with LF 8 among the single treatments, YS 4 + LF 8 among the non–irradiated combined treatments and YS 4 + γ LF 8 among the irradiated combined treatments. The differences between irradiated and non-irradiated comparables were significant for all the abovementioned parameters.

Table 5 presents the data related to the chemical fruit quality of red globe grapevine including TA%, TSS%, TSS/TA ratio and anthocyanin contents. The obtained data revealed that all single and combined treatments significantly decreased acidity% compared to the control. Among single treatments, LS 8 and LF 8 gave the least acidity%. Treatment YS 4 + LS 8 exhibited the least acidity% among non-irradiated combined treatments while YS 4 + γ LF 8 was the least among irradiated combined treatments. A significant difference between irradiated and non-irradiated comparables was detected with foliar licorice application. Moreover, all single and combined treatments significantly increased the TSS%, TSS/TA ratio and anthocyanin contents in the same manner. Among sole applications, LS 8 gave the highest values followed by LF 8. YS 4 + LS 8 and YS 4 + γ LS 8 induced the largest increase in the aforementioned parameters among non-irradiated and irradiated treatments, respectively. For TSS%, significant differences were observed between irradiated and non-irradiated comparables when licorice was soil added. For TSS/TA ration and anthocyanin contents, significant differences were noticed between all irradiated and non-irradiated comparables.

TABLE 4. Effect of yeast and gamma-irradiated licorice extracts on the physical quality and yield of red globe grapevine

Treatments	No. of sun-burned Bunches		Berry volume (cm^3)		Berry weight (g)		Bunch weight (g)		Yield (kg) per vine		yield increasing %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	9.00 a	8.00 a	10.33 h	10.63 h	11.97 h	12.23 g	416.7 k	493.3 k	12.50 k	14.80 k	0.0 m	0.0 n
YS (4g L-1)	8.00 ab	7.67 a	11.17 g	11.63 g	12.77 g	13.40 f	468.3 j	516.7 j	14.05 j	15.50 j	12.4 l	4.7 m
LS (4 g L-1)	7.67 ab	7.00 ab	11.47 f	11.93 fg	13.10 g	13.77 ef	533.3 i	548.3 i	16.00 i	16.45 i	28.0 k	11.1 l
LS (8 g L-1)	6.00 cd	5.00 cd	11.50 f	12.00 ef	13.20 g	14.13 de	555.0 h	561.7 i	16.65 h	16.85 i	33.2 j	13.9 k
LF (4 g L-1)	7.67 ab	6.00 bc	11.93 e	12.23 def	13.63 f	14.27 cd	590.0 g	603.3 h	17.70 g	18.10 h	41.6 i	22.3 j
LF (8 g L-1)	7.33 bc	5.00 cd	12.03 de	12.33 de	14.00 ef	14.30 cd	608.3 f	633.3 g	18.25 f	19.00 g	46.0 h	28.4 i
YS (4 g L-1) + LS (4 g L-1)	4.67 de	3.67 def	12.37 c	12.47 d	14.40 de	14.60 c	660.0 e	680.0 f	19.80 e	20.40 f	58.4 g	37.8 h
YS (4 g L-1) + LS (8 g L-1)	3.67 ef	2.67 ef	12.00 de	12.48 d	14.20 de	14.63 c	686.7 d	708.3 e	20.60 d	21.25 e	64.8 f	43.6 g
YS (4 g L-1.) + LF (4 g L-1)	4.67 de	4.00 de	12.27 cd	13.03 c	14.20 de	15.07 b	698.3 cd	723.3 d	20.95 cd	21.70 d	67.6 e	46.6 f
YS (4 g L-1) + LF (8 g L-1)	4.00 ef	3.33 ef	12.57 c	13.20 bc	14.57 cd	15.33 ab	710.0 c	746.7 bc	21.30 c	22.40 bc	70.4 d	51.4 d
YS (4 g L-1) + γ LS (4 g L-1)	3.67 ef	2.67 ef	12.87 b	13.17 bc	14.52 cd	15.23 b	710.0 c	733.3 cd	21.30 c	22.00 cd	70.4 d	48.6 e
YS (4 g L-1) + γ LS (8 g L-1)	3.00 f	2.33 f	13.03 ab	13.30 abc	15.17 ab	15.37 ab	731.7 b	751.7 b	21.95 b	22.55 b	75.6 c	52.4 c
YS (4 g L-1) + γ LF (4 g L-1)	4.00 ef	3.00 ef	13.10 ab	13.42 ab	14.90 bc	15.30 ab	750.0 a	760.0 ab	22.50 a	22.80 ab	80.0 b	54.1 b
YS (4 g L-1) + γ LF (8 g L-1)	3.33 ef	2.67 ef	13.33 a	13.60 a	15.37 a	15.70 a	755.0 a	771.7 a	22.65 a	23.15 a	81.2 a	56.4 a

Y; yeast, L; licorice, S; soil addition, F; foliar spray, γ; gamma-irradiated
* Means followed by the same letter/s are not significant at the 5% level.

TABLE 5. Effect of yeast and gamma-irradiated licorice extracts on the chemical berry quality of red globe grapevine

Treatments	Acidity (%)		TSS (%)		TSS/acidity ratio		Anthocyanin (mg per 100 g F.W.)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0.923 a	0.943 a	14.00 j	14.33 f	15.16 j	15.19 i	27.00 j	29.67 j
YS (4g L-1)	0.853 b	0.843 b	15.33 i	15.67 e	18.02 i	18.59 h	29.00 i	30.00 j
LS (4 g L-1)	0.807 b	0.803 c	16.00 gh	16.33 d	19.85 hi	20.37 g	35.33 h	34.67 i
LS (8 g L-1)	0.703 cd	0.710 de	17.00 de	17.00 c	24.19 ef	23.99 e	38.33 f	38.67 f
LF (4 g L-1)	0.727 c	0.723 d	15.67 hi	16.00 de	21.56 gh	22.18 f	35.67 h	36.33 h
LF (8 g L-1)	0.707 cd	0.703 e	16.33 fg	17.00 c	23.12 fg	24.21 e	37.67 g	38.00 g
YS (4 g L-1) + LS (4 g L^{-1})	0.637 ef	0.577 hi	16.67 ef	16.33 d	26.31 de	28.33 c	39.33 e	40.33 e
YS (4 g L-1) + LS (8 g L^{-1})	0.610 efg	0.567 ij	17.67 bc	17.00 c	29.00 bc	30.04 bc	41.33 bc	43.67 a
YS (4 g L-1.) + LF (4 g L^{-1})	0.663 de	0.653 f	16.67 ef	17.00 c	25.17 ef	26.11 d	38.33 f	36.67 h
YS (4 g L-1) + LF (8 g L^{-1})	0.617 ef	0.610 g	17.00 de	17.67 b	27.56 cd	28.98 bc	40.67 d	41.00 cd
YS (4 g L-1) + γ LS (4 g L^{-1})	0.623 ef	0.577 hi	17.67 bc	17.67 b	28.39 bcd	30.65 b	41.00 cd	41.33 c
YS (4 g L-1) + γ LS (8 g L^{-1})	0.557 gh	0.553 j	18.33 a	18.67 a	32.96 a	33.78 a	43.00 a	43.67 a
YS (4 g L-1) + γ LF (4 g L^{-1})	0.580 fgh	0.590 h	17.33 cd	17.00 c	29.93 b	28.81 bc	39.67 e	40.67 de
YS (4 g L-1) + γ LF (8 g L^{-1})	0.550 h	0.527 k	18.00 ab	17.33 bc	32.73 a	32.96 a	41.67 b	43.00 b

Y; yeast, L; licorice, S; soil addition, F; foliar spray, γ; gamma-irradiated

* Means followed by the same letter/s are not significant at the 5% level.

The present data showed that yeast extract improved berry volume, weight of berry and bunch as well as yield per vine. A similar result was obtained with foliar spraying of Red Globe with yeast extract, which significantly increased berry volume and weight, TSS%, TSS/acid ratio and anthocyanin content, while acidity% decreased compared to the control (El-Morsy et al., 2017 b). The increased yield and improved fruit quality can be attributed to the positive effect of yeast extract on plant growth, dry matter in reproductive parts, fruit set percentage, endogenous phytohormones, photosynthetic pigments, minerals and carbohydrates (Abou El-Yazied & Mady, 2011). The obtained results regarding the effect of licorice extract application to red globe grapevines demonstrated its positive effect on physical and chemical fruit parameters and total yield at both levels, whether added to the soil or foliar sprayed. These results are in accordance with those of El-Morsy et al. (2017 b), where foliar spraying of Red Globe with licorice extract significantly increased berry volume and weight, TSS%, TSS/acid ratio and anthocyanin content while acidity% decreased compared to the control. The stimulatory effect increased as the level of licorice extract increased, as the highest values were obtained at 20 g L^{-1}. Additionally, Alsalhy & Aljabary (2020) found that spraying Halawany grape at a level of 7.5 g $L^{-1,}$ significantly increased the cluster length, cluster number per vine, average volume of 100 berries and total yield compared to the control. They also found that levels of 2.5 and 5 g L^{-1} licorice extract significantly increased TSS%, while anthocyanin content increased in response to 2.5 and 7.5 g L^{-1} liquorice extract compared to the control.

The overall improvement of the physical and chemical fruit quality as well as yield in response to licorice extract application could be due to mevalonic acid, the biological precursor of gibberellin that expands the leaf cells, increases the leaf area and chlorophyll content and increases the ratio of berry setting (Kaplan, 2011). The increase in berry and bunch weight as well as yield was a product of increased cell division, cell enlargement due to mevalonic acid and high nutrient availability. Additionally, an efficient photosynthesis process increases the synthesis of carbohydrates and hormones in the leaves, which in turn are transmitted to all plant parts, including the clusters and finally the berries where they are stored, which leads to increase in their weight (Casanova et al., 2009). The increase in of TSS% and their ratio to acidity could be explained by their effective role in increasing the leaf area and the leaf chlorophyll content, which in turn increased carbohydrate synthesis and nutrient absorption from the soil, thus increasing the total soluble solids. The lower titratable acidity reported in trees treated with licorice extract might be attributed to acid consumption during physiological processes such as respiration (Alsalhy & Aljabary, 2020).

All combined treatments of yeast and licorice extracts were superior to single treatments, with the best one being YS 4 + γ LF 8 for physical fruit quality, yield and acidity%, while YS 4 + γ LS 8 was the best for the number of sunburn and chemical fruit quality. Foliar spraying or soil addition of a mixture of yeast and licorice extracts at levels of 15 or 20 g L^{-1} gave higher values of berry weight, volume, length and width as well as TSS%, TSS/acid ratio and anthocyanin content in addition to lower acidity % values compared to the sole application of yeast or licorice according to El-Morsy et al. (2017 b). They added that the most effective treatments were soil addition of yeast and licorice extract at levels of 20 g L^{-1} and 15 g L^{-1}, respectively.

Nutritional status parameters of red globe grapevine

Table 6 demonstrates the effect of different yeast and licorice extract applications on N%, P% and K% in the petioles of red globe grapevine. All single and combined treatments significantly enhanced N%, P% and K% compared to the control, except for sole yeast application, which did not affect K%. Among the individual treatments, LS 8 and LF 8 had the best stimulatory effect on N%, P% and K%. Additionally, the combination of LS 8 or LF 8 whether irradiated or not irradiated with yeast extract YS 4, gave the highest values of N%, P% and K%. The differences between irradiated and non-irradiated comparables were significant.

All sole licorice treatments enhanced NPK% in the petioles of red globe grapevine. These results were in accordance with Hussein & Al-Doori (2021) who sprayed strawberry plants with licorice root extract (6000 mg L^{-1}) which had a significant positive effect on the leaf content of nitrogen and phosphorous. Also, foliar spraying of red cabbage with different levels (2.5, 5 and 7.5 g L^{-1}) of licorice root extracts significantly increased nitrogen, phosphorous and potassium percentages in leaves (Sarhan & Mahmood, 2021).

TABLE 6. Effect of yeast and licorice extracts on some nutrient percentages of red globe grapevine

Treatments	N%		P%		K%	
	1st	2nd	1st	2nd	1st	2nd
Control	1.60 h	1.55 j	0.137 g	0.123 f	1.14 i	1.13 g
YS (4g L-1)	1.63 h	1.65 i	0.153 f	0.133 f	1.14 i	1.14 g
LS (4 g L-1)	1.77 g	1.69 h	0.160 ef	0.167 e	1.17 h	1.18 f
LS (8 g L-1)	1.83 f	1.79 g	0.177 e	0.187 d	1.19 g	1.20 e
LF (4 g L-1)	1.80 fg	1.70 h	0.167 ef	0.177 de	1.17 h	1.19 ef
LF (8 g L-1)	1.83 f	1.87 f	0.170 ef	0.190 d	1.18 gh	1.20 e
YS (4 g L-1) + LS (4 g L^{-1})	1.90 e	1.93 e	0.203 d	0.217 c	1.21 f	1.31 c
YS (4 g L-1) + LS (8 g L^{-1})	2.10 b	2.20 c	0.230 bc	0.247 ab	1.32 cd	1.40 b
YS (4 g L-1.) + LF (4 g L^{-1})	2.03 cd	2.00 d	0.217 cd	0.220 c	1.22 f	1.23 d
YS (4 g L-1) + LF (8 g L^{-1})	2.07 bc	2.20 c	0.230 bc	0.240 b	1.30 e	1.32 c
YS (4 g L-1) + γ LS (4 g L^{-1})	2.03 cd	2.25 b	0.230 bc	0.243 b	1.31 de	1.40 b
YS (4 g L-1) + γ LS (8 g L^{-1})	2.23 a	2.40 a	0.250 a	0.263 a	1.43 a	1.48 a
YS (4 g L-1) + γ LF (4 g L^{-1})	2.00 d	2.20 c	0.230 bc	0.243 b	1.33 c	1.40 b
YS (4 g L-1) + γ LF (8 g L^{-1})	2.10 b	2.26 b	0.240 ab	0.250 ab	1.40 b	1.47 a

Y; yeast, L; licorice, S; soil addition, F; foliar spray, γ; gamma-irradiated

* Means followed by the same letter/s are not significant at the 5% level.

Nutrient uptake of N, P and K in the shoots and seeds of pea plants was increased by increasing the concentration of licorice root extract up 5 g L^{-1} compared to the treatment not using licorice root extract in both seasons (Elrys & Merwad, 2017). This result could be attributed to the positive role of licorice root extract in increasing endogenous hormones such as GA3, which increased the role of metabolic processes and its effect on mineral content in tissue (Thanaa et al., 2016). The increment could also be due to increased leaf chlorophyll content that enhanced the uptake of nitrogen to satisfy the plant requirement, which had a positive effect on vegetative growth (Salih et al., 2021).

Conclusion

The results of the present study revealed that combination between yeast extract and licorice extract either applied to the soil or foliar were better than each one applied alone. Irradiated licorice had a more positive effect on most studied parameters as compared to unirradiated one. Some measurements improved more with licorice soil application while others improved with foliar application.

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