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Increasing Irrigation Water Use Efficiency by Adding Hundz Soil Conditioner to Improve Vegetative Growth, Fruit Quality and Yield on Flame Seedless Grapevines Under Water Stress Conditions

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THE trial was conducted during the four successive seasons of 2019, 2020, 2021, and 2022 in a vineyard in the El-Khatatba region, Lat. 29:92º, Long. 30.93º to study the influence of Irrigation scheduling and hundz soil substance to improve water use efficiency, vegetative growth, fruit quality and yield of Flame Seedless grapevines grown in sandy soil. Seven-year-old vines in sandy soil were chosen, spaced at 2 x 3 meters, irrigated by the surface drip irrigation system, and trellised by the Spanish Parron system. The experiment was designed to study the effects of different rates from soil conditioners, Hundz soil, (0.5, 1, 1.5 and 2 kg/vine) under irrigation levels at 70, 85, and 100% IWR. Hundz soil was applied to the soil under drip irrigation lines yearly. The Results showed that hundz soil substances 2 kg/vine plus an irrigation level at 85%IWR was effective in improving bud burst, bud fertility percentage, shoot length, number of leaves /shoot, and leaf area as well as enhancing yield per vine, cluster weight, berry weight, soluble solids content, and total anthocyanin while ,reducing total acidity in berries compared with irrigation level alone in four seasons of study. Additionally, water use efficiency (WUE) was improved at irrigation level at 70% IWR with 2 kg/vine and, it can save about 15% of water to achieve the same yield and fruit quality, according to the availability of water due to addition of hundz soil substances, especially under drip irrigation.

Keywords: WUE. Hundz soil, Flame Seedless, Yield, Fruit quality, Vegetative growth.

Introduction

Grapes (*Vitis vinifera* L.) are one of the most important and widely cultivated fruit crops in Egypt. It ranks the fourth after olives with a cultivated area of about172,533.6 feddans with an annual totalproduction of about 1,586,342 tons (FAO, 2020).

Flame seedless' *Vitis vinifera* L. is considered as one of the most widely cultivated seedless cultivars worldwide. Also, it is produced in different regions and under various conditions such as Australia, Brazil, Chile, Egypt, India, Mexico, South Africa, and the USA. Botanically, Flame seedless vines have very vigorous growth and fruit clusters are bright red color, berries are large to medium in size and seedless. Berries quality has a crisp skin, juicy pulp, and distinctive Muscat flavor and fast early growing cultivar is an early-season harvest of sweet and large berries (Brooks and Olmo, 1997).

Irrigation in viticulture is the process of applying the required amount of water to the vine yard. Additionally, sandy soils have unique management issues because of their high permeability and poor ability to hold water and nutrients. Physiologically grapevines, the amount of available water affects photosynthesis and hence growth, as well as the development of grape berries (Torres et al., 2021a). Also, irrigation is an effective way of regulating the availability of water for grapevines

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and consequently their yield. (Chaves et al., 2002). Consequently, the optimization of water apply by scheduling irrigation for grapevine leads to improve water use efficiency (WUE), and ensuring sustainability in grapes is a key topic of respect. As a result, a significant amount of basic and applied study has been devoted to investigating how to best use water of grapevine. The study of irrigation time and schedule by introducing innovative technology to reduce water usage is a significant component of these studies (Romero et al. 2004; Sadras 2009; Chaves et al. 2010; Williams et al. 2010). In this respect, (El-beltagy *et al.,* (2017) tested three irrigation treatments i.e. 60, 80 and 100% of reference evapotranspiration and two fertigation programs i.e. farm fertigation program (F1) and new proposed fertigation program (F2). The irrigation treatment (80% of ET0) resulted in the maximum values of all vegetative parameters.

Soil conditioners are the most effective agents in stabilizing soil organic matter (El-Aggory and Abd ElRasoul, 2002). Hundz soil is a natural soil conditioner that is made out of dry compressed cellulose and recycles agricultural material, has a balanced pH of 6.8-7.2, is shaped like grains and ranges in size (0.2-2.0mm), is able to penetrate sand grains to create a new media that is perfect for growing plants, and has a water holding capacity that will change sandy soil's water capacity and does not absorb heat, which significantly reduces water evaporation. Hundz soil is an organic soil conditioner that needs half as much water to grow crops and makes it possible to grow crops in dry or damaged areas Melito et al 2019 . Hundzsoil retains water longer than regular soil, so plants develop healthy root system. Hundz soil is certified from Soil, Water and Environment Res., Institute, ARC, Giza Egypt. Eman (2011) found that the effects of different rates from soil conditioners, such as Hundz soil, (0.0,0.5 and 10Kg /tree) or mixture from (Nile fertile + K2SO4) [Zero, (2Kg + 500gm) and (1Kg + 250gm)] under irrigation levels at 50, 75 and 100% of the recommended water level (5.5, 8.25 and 11m^3 /tree /year) as well as their interactions on growth, leaf component, flowering, fruiting, yield and fruit quality during both seasons and application of either Hundz soil at rate of 10kg / tree or the mixture of (NF + K2SO4) at highest rate (2Kg + 500gm) gave significantly the highest mean values of the above mentioned characters during the two years. In this context, the evaluation of the best combination among irrigation systems and natural soil conditioners (Hundz soil) of Rosemary, Khorshidi et al. (2009)

The objective of the present investigation was to study possibility of reducing the irrigation amount by using Hundz soil with no adverse effects vegetative growth, fruit quality and yield of Flame Seedless grapes.

Materials and Methods

The trial was conducted during the four successive seasons of 2019, 2020, 2021, and 2022 in a vineyard in the El-Khatatba region, Minufyia Governorate, Egypt. Lat. 29:92^o, Long. 30.93^o. Seven-year-old vines in sandy soil were chosen, spaced at 2 x 3 meters, irrigated by the drip irrigation system, and trellised by the Spanish Parron system. Vines were trained to form quadrilateral cordons. The vines were pruned through the last week of December, leaving 12 spurs with 5 buds plus 4 replacements spurs with 2 buds. The total bud load was 68 buds. Ninety nine vines were regularly selected for this investigation with as similar vigor as possible. All grapevines were given the same cultural administration recommended by the ministry of agriculture and land reclamation, such as fertilization, irrigation, disease management, and pest management. The investigation included elven treatments coordinated in a complete randomized block design; each treatment was replicated three times and included 3 vines/replicate . -Hundz soil conditioner was used at four levels:(0.5, 1, 1.5 and 2 kg/vine) under irrigation levels at 70, 85 and 100% (IWR) Irrigatioon Water Requirement .Hundz soil was applied to the soil under drip irrigation lines in January of each year. The chemical analysis of Hundz soil is shown in Table 1.

This study included the following eleven treatments, as follows:

1- Irrigation at 100% irrigation Water Requirement IWR (control) + without any addition of Hundz soil

2-Irrigation at 85% IWR +without any addition of Hundz soil

3-Irrigation at 85% IWR +½kg/vine Hundz soil

4- Irrigation at 85% IWR +1kg/ vine Hundz soil

5- Irrigation at 85% IWR +1½kg/ vine Hundz soil

6- Irrigation at 85%+2kg/ vine Hundz soil

7- Irrigation at 70% IWR+ without any addition Hundz soil

8-Irrigation at 70% IWR +½kg/ vine Hundz soil

9- Irrigation at 70% IWR +1kg/ vine Hundz soil

10- Irrigation at 70% IWR +1½kg/ vine Hundz soil

11- Irrigation at 70% IWR +2kg/ vine Hundz soil

TABLE 1. Some physical and characteristics properties of Hundz soil (conditioner)

Analysis	Unit	Values
Weight of a cubic meter	Kg	280
Moisture	%	42
pH (10:1)		7.21
EC(10:1)	(dS/m)	0.81
Total nitrogen	%	0.25
Organic matter	%	78.39
Organic carbohydrate	%	45.47
Ash	%	21.61
NC:N		1:181.88
(Fu: A)Total phosphorus	%	0.075
(p o) Total potassium	%	0.14
Saturation Capacity	%	307
Grass seeds	--	---
Nematodes:		
Plant pathogen	Larva/200g	----
free non- nurse	Larva/200g	-----

During the four seasons, the following measurements were verified:

Bud behavior

Bud burst %

Number of bud were counted one month after bud burst and the percentage of bud burst were calculated as follows according to Bessis (1960).

Bud burst%=

$$\frac{\text{No of bursted buds per vine}}{\text{Total buds per vine left on the vine at pruning time}} \times 100$$

Bud fertility %

Number of clusters per vine were counted and divided by the total number of buds and the fertility was calculated as follows according to Bessis(1960).

Bud fertility% =

$$\frac{\text{No of clusters per vine}}{\text{Total buds per vine left on the vine at pruning time}} \times 100$$

Fruiting coefficient

This was calculated according to the equation (No. of clusters/total number of buds burst) left on the vine at pruning time as mentioned by Bessis (1960). It can he noted that this parameter was determined in the following year each season**.**

Vegetative growth parameters

From non-fruiting shoots at full bloom, the vegetative growth parameters were assessed. Average shoot length (cm), number of leaves per shoot, and average leaf area (cm^2) were among the factors that were evaluated**:** from seventh leaf from the top of the growing shoot, a sample of four mature leaves from each treated vine were taken and used to calculate the leaf area (cm^2)**:** Sample of four mature leaves from each treated vine (7^{th} leaf from the top of the growing shoot) were collected and used for measuring leaf area according to the equation of Montero et al., (2000):

Leaf area (cm^2 / leaf) = 0.587 (L × W)

Where, L= Length of leaf blade. W= Width of leaf blade

N, P and K content in leaf petioles

N, P and K content was determined at full bloom using samples of 20 leaf petioles per replicate collected from leaves opposite the cluster as mentioned by Cottenie et al.(1982).

Physical characteristics berries

-Average cluster weight (g).

-Average 25 berry weights (g).

-Yield /vine =number of clusters/vine × average cluster weight.

Chemical characteristics berries:

-Total Soluble Solids (T.S.S. %) was measured in the juice by hand refractometer A.O.A.C. (2006)

-Titratable acidity (as gram tartaric acid/100 ml

juice) by titration NaOH using phenolphthalein such as an indicator, (Iland, 2000)
-Total anthocyanin's of the berries skin (mg/100g f.w.) according to Husia et al., (1965)

Dormant season studies:
a-Coefficient of wood ripening

Twelve shoots for each replicated were select to measurement the coefficient of wood ripening, which was calculated by dividing length of the ripened part by the total length of the shoot according to Rizk and Rizk, (1994).

b- Pruning weight/vine (g):

It was determined at dormancy period (winter pruning) according to Selim et al (1978).

c-Total carbohydrates in cane (%)

Total carbohydrates in fruiting canes were determined calorimetrically by using reagent according to the method described by DuBois et al., (1956). Total carbohydrates content were determined using the glucose standard curve as g. glucose/100 g dry weight.

Irrigation and soil

Drip irrigation system was implemented and irrigation was applied according to the cumulative values of the daily crop water requirement (CWR) calculated from reference evapotranspiration (ETo) using weather data of study site. Application of irrigation regime treatments started from the second irrigation and treatments were as follows: (I_1) 100%; (I_2) 85% and (I_3) 70% of CWR. Each irrigation treatment has one lateral line with two drippers per tree (4 liters per hour) and one valve for each lateral line was used to control the amount of applied water.)

The soil samples were collected of the experimental site from consecutive four depths (0-30 till 120 cm depths) for physical and chemical analysis of the soil. The chemical properties of the soil samples; were determined according to the methods outlined by Page et al (1982). Particle size distribution according to Gee and Bauder, (1986). Field capacity was determined according to Cassel and Nielsen, (1986). Wilting point was determined according to Stakman and Vanderhas ,(1962). Available water was calculated from the values of field capacity and wilting point. Bulk density was determined according to Blake and Hartge, (1986a). Physical and chemical analyses data and soil water contents of the soil are shown in Table 2.

Water relations
Irrigation Water Applied (IWA)

The irrigation water applied for grape vines during the studied seasons; were calculated

TABLE 2. Soil characteristics of the experiment site .

Soil properties	Value
1- Particles size distribution (%)	
Course sand	36.31
Fine sand	51.87
Silt	4.91
Clay	6.81
Texture class	Sand
2- Chemical properties	
O. M (%)	0.871
EC dSm^{-1}	0.11
pH 1:2.5 soil : water suspension	7.6
Available N (KCl-extract)	18.10
Available P (Na - bicarbonate extract)	27.00
Available K (NH4 - a acetate extract)	33.00
Soil moisture constants (% by weight) and bulk density (g cm^{-3})	
Depth, cm	0-75
Field capacity %	19.4
Wilting point %	7.8
Bulk density (g cm-3)	1.41
Available water (mm)	80.4

TABLE 3. Some meteorological data at experimental site, at 2019,2020, 2021 and 2022 seasons.

Month	Tmax (oC)	Tmin	RH	WS	RF	SS	Rad	Eto
				2019				
January	6.2	19.8	52	207	2.9	7.8	13.9	2.9
February	6.6	21.8	44	213	5.6	8.0	16.3	3.7
March	8.0	22.0	44	230	7.0	8.5	19.6	4.3
April	13.8	30.7	35	277	1.7	9.3	22.8	6.8
May	17.5	34.5	31	268	0.0	10.3	25.3	8.0
June	20.3	36.9	31	277	0.0	11.2	26.9	8.9
July	21.3	37.1	36	225	0.0	11.1	26.5	8.0
August	21.4	36.8	38	207	0.0	10.8	25.3	7.5
September	19.4	34.4	43	216	0.0	9.9	22.1	6.5
October	16.2	30.3	46	216	0.0	9.1	18.3	5.2
November	10.6	25.5	51	181	0.8	8.4	14.9	3.6
December	6.6	20.7	55	199	6.3	7.9	13.3	2.8
Mean	13.9	29.2	42	226	24.3	9.3	20.4	5.66
				2020				
January	7.9	20.9	63	337	2.6	8.6	14.5	3.17
February	7.9	21.3	65	294	12.0	9.9	18.1	3.4
March	9.1	22.9	64	337	3.5	10.5	21.9	4.29
April	11.0	28.7	52	372	1.9	11.7	26.1	6.51
May	17.2	35.8	40	346	0.0	12.1	27.9	8.85
June	18.9	36.2	45	363	0.0	13.2	29.8	9.17
July	21.9	38.6	45	337	0.0	13.5	30	9.51
August	22.3	39.3	47	311	0.0	13.4	28.9	9.11
September	20.6	35.6	52	354	0.0	12.8	25.8	7.9
October	17.4	31.2	56	320	0.0	11.6	21	5.79
November	14.8	27.4	64	285	4.9	10.3	16.5	4.01
December	8.8	19.0	70	337	6.0	9.1	14.0	2.62
Mean	14.8	29.7	55	333	32.2	11.4	22.9	6.19
				2021				
January	8.3	21.5	59.0	259.0	3.0	7.1	12.6	2.98
February	8.2	21.7	60.0	173.0	4.6	7.8	15.6	2.94
March	9.2	23.3	62.0	259.0	6.7	8.4	19.1	3.94
April	11.6	29.2	51.0	259.0	3.8	9.4	22.8	5.66
May	17.9	36.8	37.0	259.0	0.0	10.4	25.4	7.96
June	19.4	39.9	41.0	346.0	0.0	11.8	27.7	9.76
July	22.5	39.3	41.0	259.0	0.0	11.6	27.2	8.68
August	22.9	39.7	43.0	259.0	0.0	11.1	25.5	8.39
September	20.9	36.0	51.0	259.0	0.0	10.3	22.3	6.86
October	17.7	31.5	55.0	259.0	0.8	9.2	18.0	5.21
November	15.2	27.8	62.0	259.0	2.6	8.0	14.0	3.84
December	9.0	19.7	66.0	259.0	4.2	6.8	11.6	2.53
Mean	15.2	30.5	52.0	259.0	25.7	9.3	20.1	5.73
				2022				
January	8.0	17.0	54.0	380.0	4.1	9.1	14.8	3.3
February	8.3	18.2	57.0	328.0	10	9.9	18.1	3.5
March	10.0	20.5	58.0	372.0	2.3	10.5	21.9	4.4
April	12.4	23.9	51.0	380.0	0.8	10.9	25.0	5.7
May	17.7	29.0	38.0	389.0	0	11.2	26.6	7.9
June	21.6	32.6	44.0	372.0	0	12.1	28.2	8.5
July	22.5	36.7	46.0	337.0	0	12.6	28.7	9.0
August	22.9	36.1	47.0	311.0	0	12.8	28.0	8.5
September	21.1	34.2	53.0	320.0	0	12.1	24.8	7.2
October	19.1	33.0	59.0	320.0	0	11.8	21.2	5.9
November	15.4	29.1	57.0	302.0	1.8	10.5	16.7	4.7
December	10.1	21.5	65.0	372.0	5.3	9.6	14.4	3.3
Mean	15.8	27.7	52	348	24.3	11.1	22.4	5.98

Tmax and Tmin = maximum and minimum air temperatures (°C); RH= relative humidity %; WS= wind speed (km/h); RF = rainfall (mm / month); SS = actual sun shine (h); Red=solar radiation MJ/M^3/day; Eto = reference evapotranspiration (mm day^{-1}).

by computing the estimated reference evapotranspiration (ETo) using Penman- Monteith equation included in "CROPWAT 8" model as described in FAO 56 according to Allen et al. (1998)

Then, crop evapotranspiration (ETc) was calculated using crop coefficient.

Finally, Irrigation water applied was calculated according to Vermeiren and Jopling (1984).

$$IWA = \frac{ETc \times IxKr}{Ea \times (1-LR)}$$

Where:

IWA = Irrigation water requirements (mm and m^3/ feddan).

ETc= Crop evapotranspiration (mm day^{-1}).

I= irrigation intervals (days)

K_r = reduction factor that depends on ground cover. K_r value of 1.0 was used since crops spacing were less than 1.8 m a part.

Ea = irrigation application efficiency of the drip irrigation system (90%).

LR= Leaching requirements (assumed 10% from total irrigation water amount).

Water consumptive use (WCU)

Water consumptive use (CU) was estimated via soil samples from the sub plots just before each irrigation and 8 hrs later as well as at harvest. Sampling depths were 15-cm successive layers down 60-cm depth of the soil profile. The CU was calculated according to Israelsen and Hansen (1962) as follows:

$CU = (\theta 2 - \theta 1)/100 \times Bd \times D$

Where:

CU = Water Consumptive Use (in mm).

D = effective root depth (in mm).

Bd = bulk density of soil in (g/cm^3).

θ_2 = Soil moisture percentage 8 hr after irrigation (w/w).

θ_1 = Soil moisture percentage before next irrigation (w/w).

Then, the seasonal water use values were obtained from the sum of the WCU of all irrigations under different treatments at both growing seasons.

Irrigation water productivity (IWP)

Irrigation water productivity (IWP) was calculated according to the following formula:

$$IWP = \frac{\text{Weights yield (kg/fed)}}{\text{Water Irrigation Applied (m}^3\text{/fed)}}$$

Water use efficiency (WUE)

Water use efficiency refers to (kg dry weight/ m^3 of water consumed) was calculated according to Jensen (1965). as follows:

$$WUE = \frac{\text{Weight yield (kg/fed)}}{\text{Seasonal WCU (m}^3\text{/fed)}}$$

Costs and net profit /feddan

Yield/ feddan ton (average four seasons) = Yield (kg fruit/vine) x Number of vines/1000.

Total costs / feddan (L.E.) = Treatments costs/ feddan (L.E.) + Costs of cultural practices/ feddan (L.E.).

Total production/ feddan (L.E.) = Yield/ feddan ton x price of one ton.

Net profit / feddan (L.E.) = Total production/ feddan (L.E.) - Total costs / feddan (L.E.).

Statistical Analyses

Completely randomized block design (CRBD) with three replications was used to design the experiment. Least significant difference test was used to compare means using the statistical analysis software; CoStat (CoHort Software, U.S.A) version 6.4. The values of probability $p \leq 0.05$ were considered statistically significant based on the least significant difference test

Results

Bud behavior

Data in Table 4 clearly display that using Hundz soil for a specific irrigation level resulted in significantly higher magnitudes of the afore mentioned parameters than not using for the same level. Also, there was a gradual significant increase in these parameters by increasing the quantity used of Hundz soil for the same irrigation levels. Irrigation level with hundz soil of Flame seedless grapevines gave the highest values of bud burst, bud fertility percentage, and Fruiting coefficient in four seasons, respectively, as compared with irrigation level alone. With respect to the effect of adding hundz soil substance, there was a gradual and significant increase in the percentage of bud burst, bud fertility percentage, and Fruiting coefficient as a result of increasing hundz soil substance from 0.5 kg/vine to 2 kg/vine.

The same table's data show that the irrigated vines at 85% and treated with 2 kg per vine hundz soil had the highest values on bud burst, bud fertility percentage, and Fruiting coefficient compared with other treatments in all four seasons followed by irrigation level at 70% +2kg/vine hundz soil, respectively. While the vines that were irrigated at 100% (the (control) gave the significant lowest values of bud burst, bud fertility percentage, and Fruiting coefficient in all four years.

Vegetative growth parameters

The data in Table 5 show that, in the four years, the application of Hundz soil at any of the considered quantities to an irrigation, significantly improved all growth parameters, including shoot length, number of leaves per shoot, and leaf area, as compared with irrigation levels alone. The application of hundz soil at a high dose (2 kg/vine) was significantly superior to the use of other doses (0.5, 1, or 1.5 kg/vine). The significant highest values of all vegetative growth characteristics (shoot length, number of leaves per shoot, and leaf area) were obtained by adding hundz soil at 2 kg/vine plus an irrigation level at 85%, whereas the significant least values were attributed to the irrigation level at 100% (control) in all four years.

Physical characteristics of cluster

Regarding the effect of adding hundz soil under drip irrigation lines in January with the irrigation level on cluster weight, length, and width of Flame Seedless grapes, the data in Table 6 reveale a significantly positive effect in all four years. The highest magnitudes of the afore mentioned parameters were attributed to irrigation level of 85% with hundz soil 2 kg per vine, followed by an irrigation at 70% with hundz soil 2kg per vine for the four seasons, as compared with other treatments in the four seasons of study. However, soil application of hundz soil at 2 kg/vine with any irrigation level was more effective in this regard than that at 0.5, 1, or 1.5 kg/vine with same irrigation level.

Yield per vine, 25 berry size and 25 berry weight:

The data in Table 7 show that, for the four seasons of the study, the application of an irrigation level with any of the doses of hundz soil, improved yield per vine, 25 berry size, and 25 berry weight as compared with the considered irrigation level alone. The highest dose of hundz increased these parameters compared to the other doses, highest values of these attributes was induced by using Hundz soil with the 85% irrigation regime. Whereas, the irrigation level at 100% (control) induces the significant lowest values of these ones in all four seasons.

Berry length, and diameter

Findings in Table 8 showed that, the application of irrigation level with all doses of hundz soil, significantly increased berry length, and diameter as compared with the same irrigation level 100% (control) in four seasons. The application of hundz soil at highest dose (2 kg/vine) significantly improved these parameters compared using lower dosages (0.5, 1, or 1.5 kg/vine). The addition of hundz soil substances at 2 kg/vine plus an irrigation level of 85% followed by the use of the irrigation level at 70% with 2 kg / vine hundz soil showed highest significant values of berry length, and diameter, whereas the irrigation level at 100% (control) produced the lowest significant values of these ones in all four seasons.

Chemical characteristics of berries

Referring to Table 9, it is obviously noticed that all chemical characteristics of berries, berries, including total soluble solids% (TSS), total acidity%, and total anthocyanin%, were significantly affected by the application of irrigation levels to all doses of hundz soil as compared with irrigation levels alone in four seasons. The application of hundz soil at a high dose (2 kg/vine) had the best results as compared to the other dosages (0.5, 1, or 1.5 kg/vine). The addition of hundz soil substances (2 kg/vine) plus an irrigation level at 85% significantly achieved the highest values of TSS, and anthocyanin of berry skin, as well as the least acidity values of berry juice, whereas the irrigation level at 100% (control) had the least values of TSS, and anthocyanin of berry skin, as well as the highest acidity values of berry juice in four seasons.

Dormant season studies

The soil application of hundz soil significantly enhanced the studied parameters i.e,pruning wood weight, ripening wood coefficient, and total carbohydrates in canes as compared with the same irrigation level alone (Table 10). However, soil application of hundz soil at (2 kg/vine) was more effective than soil application of hundz soil at 0.5, 1, or 1.5 kg/vine. The highest values of pruning wood weight, ripening wood, and total carbohydrates in canes were observed in vines that were irrigated at 85% with 2 kg per vine, followed by those irrigated at 70% with 2 kg per vine in four seasons

TABLE 4. Effect of irrigation levels with hundz soil substance on bud burst percentage, bud fertility percentage and fertility coefficient of Flame seedless grapevines during 2019, 2020, 2021, and 2022.

Treatments	Bud burst percentage				Bud fertility percentage				Fruiting coefficient			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	85.67	86.67	88.67	93.67	57.00	59.67	66.67	68.33	0.52	0.55	0.52	0.53
Irrigation at 85% IWR+ without Hundz soil	85.67	85.67	87.67	89.67	53.33	56.67	60.77	65.00	0.4	0.45	0.5	0.5
Irrigation at 85% IWR +½kg/vine Hundz soil	85.67	87.67	89.67	91.67	62.33	64.00	67.33	70.00	0.55	0.57	0.48	0.52
Irrigation at 85% IWR +1kg/ vine Hundz soil	86.67	88.67	90.67	92.67	63.67	66.00	69.33	72.67	0.58	0.6	0.5	0.57
Irrigation at 85% IWR +1½kg/ vine Hundz soil	87.67	89.67	91.67	93.67	65.33	69.33	70.33	73.33	0.61	0.63	0.52	0.58
Irrigation at 85% IWR +2kg/ vine Hundz soil	88.67	90.67	92.67	94.67	67.67	73.33	75.33	77.67	0.64	0.66	0.57	0.62
irrigation at 70% IW+ without Hundz soil	82.33	84.33	86.33	88.33	56.00	58.00	64.33	66.67	0.52	0.53	0.5	0.49
Irrigation at 70% IWR +½kg/vine Hundz soil	83.33	85.33	87.33	89.33	61.33	63.33	68.33	71.67	0.54	0.55	0.48	0.51
Irrigation at 70% IWR +1kg/ vine Hundz soil	84.67	86.67	88.67	89.33	62.33	65.00	69.00	72.00	0.58	0.6	0.51	0.55
Irrigation at 70% IWR +1½kg/ vine Hundz soil	86.33	88.33	91.33	90.33	64.67	67.67	68.33	72.67	0.6	0.61	0.51	0.57
Irrigation at 70 % IWR +2kg/ vine Hundz soil	88.67	90.33	92.00	92.33	66.00	70.00	73.00	76.67	0.62	0.64	0.55	0.6
L.S.D at 5%	**1.51**	**1.47**	**1.45**	**1.92**	**3.75**	**5.30**	**5.86**	**6.07**	**0.04**	**0.04**	**0.08**	**0.05**

TABLE 5. Effect of irrigation levels with hundz soil substance on shoot length, number of leaves per shoot, and leaf area, of Flame seedless grapevines during 2019, 2020, 2021, and 2022.

Treatments	Shoot length (cm)				N. of leaves/shoot				Leaf area (cm^2)			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	245.67	248.33	248.67	251.33	29.3	31.3	33.3	36.0	174.33	182.00	188.00	191.67
Irrigation at 85% IWR+ without Hundz soil	245.00	247.33	248.33	251.33	29.0	31.6	33.6	35.3	173.67	179.33	183.00	187.00
Irrigation at 85% IWR +½kg/vine Hundz soil	245.00	247.67	249.00	249.67	27.0	31.0	33.3	35.6	177.33	183.67	190.67	192.33
Irrigation at 85% IWR +1kg/ vine Hundz soil	245.67	248.33	249.67	251.67	30.3	33.0	34.3	37.0	182.67	190.67	193.33	192.67
Irrigation at 85% IWR +1½kg/ vine Hundz soil	247.33	249.33	250.00	256.67	33.0	34.0	35.0	36.3	186.00	193.00	194.00	196.00
Irrigation at 85% IWR +2kg/ vine Hundz soil	249.00	251.00	252.67	258.33	33.3	34.6	38.6	40.3	190.00	196.67	198.33	199.00
irrigation at 70% IW+without Hundz soil	240.33	247.33	249.00	251.67	25.0	27.3	29.6	32.0	173.67	178.00	184.33	186.67
Irrigation at 70% IWR +½kg/vine Hundz soil	239.67	242.00	246.33	248.67	26.3	28.0	30.0	32.3	173.33	176.33	180.33	186.67
Irrigation at 70% IWR +1kg/ vine Hundz soil	246.33	248.00	249.67	251.67	29.3	32.0	33.3	36.0	181.67	190.33	192.67	195.00
Irrigation at 70% IWR +1½kg/ vine Hundz soil	246.67	248.67	250.00	253.33	30.3	32.6	34.6	36.0	184.00	191.33	192.00	194.67
Irrigation at 70 % IWR +2kg/ vine Hundz soil	248.00	250.33	252.00	255.00	33.0	34.0	37.0	39.6	185.00	194.33	196.67	198.33
L.S.D at 5%	**2.40**	**1.86**	**1.88**	**3.75**	**1.96**	**1.52**	**2.11**	**2.19**	**4.92**	**3.90**	**4.09**	**4.22**

TABLE 6. Effect of irrigation levels with hundz soil substance on cluster weight, length and width of Flame seedless grapes during 2019, 2020, 2021, and 2022

Treatments	Cluster weight (g)				Cluster length (cm)				Cluster width (cm)			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	536.6	545.0	555.0	571.3	19.33	20.33	21.33	22.67	15.33	16.00	17.33	17.67
Irrigation at 85% IWR+ without Hundz soil	501.6	535.0	550.0	570.0	18.67	19.67	20.67	21.67	15.00	16.00	17.00	17.33
Irrigation at 85% IWR +½kg/vine Hundz soil	561.6	576.6	585.0	591.6	19.67	20.67	21.67	22.67	16.00	16.67	17.00	17.33
Irrigation at 85% IWR +1kg/ vine Hundz soil	565.0	568.3	588.3	603.3	20.67	21.67	22.67	23.67	16.33	16.67	17.00	17.67
Irrigation at 85% IWR +1½kg/ vine Hundz soil	573.3	583.3	595.0	613.3	21.00	22.00	23.00	23.33	17.00	17.00	17.67	18.00
Irrigation at 85% IWR +2kg/ vine Hundz soil	610.0	616.6	630.0	638.3	22.33	23.33	23.67	24.00	17.33	17.33	18.00	18.33
irrigation at 70% IW+ without Hundz soil	466.6	500.0	535.0	550.0	18.00	19.33	20.33	21.33	14.33	15.00	16.00	16.33
Irrigation at 70% IWR +½kg/vine Hundz soil	526.6	573.3	583.3	586.6	19.67	20.67	21.67	22.67	15.67	16.33	16.67	17.00
Irrigation at 70% IWR +1kg/ vine Hundz soil	546.6	591.6	596.6	596.6	20.67	21.67	22.67	23.00	16.33	16.67	16.67	17.33
Irrigation at 70% IWR +1½kg/ vine Hundz soil	571.6	598.3	610.0	610.0	20.67	21.67	21.67	23.33	16.67	16.67	17.00	17.67
Irrigation at 70 % IWR +2kg/ vine Hundz soil	593.3	606.6	616.6	635.0	21.67	22.67	23.33	23.67	17.00	17.00	17.67	18.00
L.S.D at 5%	**26.34**	**22.06**	**16.13**	**16.85**	**0.68**	**0.65**	**0.63**	**0.58**	**1.96**	**2.59**	**1.77**	**2.38**

TABLE 7. Effect of irrigation levels with hundz soil substance on yield/vine, 25 berries size and 25 berries weight of Flame seedless grapes during 2019, 2020, 2021, and 2022

Treatments	Yield/ vine (kg)				25 berries size (cm^3)				25 berries weight (g)			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	16.10	16.35	16.65	17.05	80.3	82.3	84.3	86.3	87.00	88.00	88.33	89.00
Irrigation at 85% IWR+ without Hundz soil	15.05	16.05	16.50	17.10	78.3	84.0	84.3	85.0	86.00	87.33	87.67	88.33
Irrigation at 85% IWR +½kg/vine Hundz soil	16.85	17.30	17.55	17.75	82.3	84.3	86.3	88.3	87.00	88.33	88.67	90.00
Irrigation at 85% IWR +1kg/ vine Hundz soil	16.95	17.05	17.65	18.10	84.3	86.3	88.3	90.3	88.67	90.00	90.67	91.00
Irrigation at 85% IWR +1½kg/ vine Hundz soil	17.20	17.50	17.85	18.40	86.3	88.3	90.3	90.6	91.67	92.00	92.33	92.67
Irrigation at 85% IWR +2kg/ vine Hundz soil	18.30	18.50	18.90	18.85	88.3	90.3	91.6	92.0	92.00	92.33	92.67	93.00
irrigation at 70% IW+ without Hundz soil	14.00	15.00	16.05	16.50	77.3	80.0	81.3	83.3	85.00	85.67	86.00	86.33
Irrigation at 70% IWR +½kg/vine Hundz soil	15.80	17.20	17.50	17.60	80.3	84.0	84.6	86.6	86.67	88.00	88.33	88.67
Irrigation at 70% IWR +1kg/ vine Hundz soil	16.40	17.75	17.90	17.90	82.3	84.6	86.6	88.6	88.33	89.67	90.00	90.67
Irrigation at 70% IWR +1½kg/ vine Hundz soil	17.15	17.95	18.03	18.30	84.3	86.3	88.3	90.3	90.67	91.67	91.67	91.67
Irrigation at 70 % IWR +2kg/ vine Hundz soil	17.80	18.20	18.50	18.85	86.3	88.3	90.3	91.3	91.67	92.00	92.33	92.67
L.S.D at 5%	**0.761**	**0.662**	**0.450**	**0.463**	**0.57**	**2.24**	**1.57**	**1.27**	**2.37**	**2.89**	**2.89**	**2.04**

TABLE 8. Effect of irrigation levels with hundz soil substance on berry length, and diameter of Flame seedless grapes during 2019, 2020, 2021, and 2022

Treatments	Berry length (mm)				Berry diameter (mm)			
	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	19.33	19.67	20.00	20.33	19.33	19.67	20.00	20.33
Irrigation at 85% IWR+ without Hundz soil	19.00	19.33	19.67	20.00	19.00	19.67	19.67	20.00
Irrigation at 85% IWR +½kg/vine Hundz soil	19.67	20.00	20.33	20.67	19.67	20.00	20.33	20.67
Irrigation at 85% IWR +1kg/ vine Hundz soil	20.00	20.33	20.67	21.33	20.00	20.33	20.33	21.33
Irrigation at 85% IWR +1½kg/ vine Hundz soil	20.33	20.67	21.33	21.67	20.33	20.67	21.33	21.67
Irrigation at 85% IWR +2kg/ vine Hundz soil	21.00	21.33	21.67	22.00	21.00	21.33	21.67	22.00
irrigation at 70% IW+ without Hundz soil	18.67	19.00	19.33	19.67	18.67	19.00	19.33	19.67
Irrigation at 70% IWR +½kg/vine Hundz soil	19.00	19.33	19.67	20.67	19.00	19.33	19.67	20.67
Irrigation at 70% IWR +1kg/ vine Hundz soil	19.33	19.67	20.00	21.00	19.33	19.67	20.00	21.00
Irrigation at 70% IWR +1½kg/ vine Hundz soil	20.00	20.33	20.67	21.33	20.00	20.33	20.67	21.33
Irrigation at 70 % IWR +2kg/ vine Hundz soil	20.67	21.00	21.33	21.67	20.67	21.00	21.33	21.67
L.S.D at 5%	**0.82**	**0.76**	**0.68**	**0.58**	**0.82**	**0.77**	**0.68**	**0.58**

TABLE 9. Effect of irrigation levels with hundz soil substance on T.S.S, Acidity and total anthocyanin of Flame seedless grapes during 2019, 2020, 2021, and 2022

Treatments	T.S.S (%)				Acidity (%)				Total anthocyanin (mg/100g F.W)			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	17.67	18.00	18.67	19.33	0.77	0.80	0.73	0.67	19.00	32.67	37.67	42.67
Irrigation at 85% IWR+ without Hundz soil	17.67	18.67	18.67	19.33	0.80	0.73	0.73	0.67	18.67	25.00	30.00	35.00
Irrigation at 85% IWR +½kg/vine Hundz soil	17.00	18.00	18.67	19.67	0.80	0.73	0.73	0.63	21.00	27.00	32.00	36.00
Irrigation at 85% IWR +1kg/ vine Hundz soil	17.67	18.33	19.00	19.67	0.80	0.77	0.70	0.67	24.00	28.67	34.67	39.67
Irrigation at 85% IWR +1½kg/ vine Hundz soil	17.67	18.67	19.00	19.67	0.80	0.73	0.70	0.63	26.00	31.33	37.00	42.00
Irrigation at 85% IWR +2kg/ vine Hundz soil	22.33	19.33	19.33	19.33	0.67	0.67	0.70	0.67	28.00	31.33	39.00	44.00
irrigation at 70% IW+ without Hundz soil	16.67	17.67	18.67	19.00	0.83	0.80	0.73	0.70	18.00	23.00	28.00	33.00
Irrigation at 70% IWR +½kg/vine Hundz soil	19.33	19.33	19.67	19.67	0.67	0.67	0.63	0.63	22.33	28.67	33.33	38.33
Irrigation at 70% IWR +1kg/ vine Hundz soil	18.67	19.00	19.00	19.67	0.73	0.70	0.70	0.63	26.00	29.67	36.33	41.33
Irrigation at 70% IWR +1½kg/ vine Hundz soil	19.33	20.00	19.67	20.00	0.67	0.63	0.60	0.57	28.00	32.00	36.33	41.33
Irrigation at 70 % IWR +2kg/ vine Hundz soil	20.00	20.00	20.33	20.33	0.60	0.60	0.53	0.50	29.67	34.00	37.67	42.67
L.S.D at 5%	**1.96**	**0.74**	**0.54**	**0.59**	**0.05**	**0.07**	**0.05**	**0.06**	**1.68**	**1.36**	**1.31**	**1.27**

TABLE 10. Effect of irrigation levels with hundz soil substance on ripening wood coefficient, pruning wood weight, and total carbohydrates in canes of Flame seedless grapevines during 2019, 2020, 2021, and 2022

Treatments	Ripening wood coefficient				Pruning wood weight (k g)				Total carbohydrates in canes(g/100gDW)			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	0.79	0.84	0.87	0.88	2.783	2.850	2.973	3.167	27.94	28.57	28.72	29.20
Irrigation at 85% IWR+ without Hundz soil	0.79	0.82	0.86	0.87	2.717	2.817	2.950	3.133	27.65	28.32	28.65	29.18
Irrigation at 85% IWR +½kg/vine Hundz soil	0.82	0.85	0.88	0.89	2.833	2.950	3.083	3.300	28.28	28.50	28.77	29.07
Irrigation at 85% IWR +1kg/ vine Hundz soil	0.83	0.86	0.89	0.89	2.917	3.033	3.123	3.320	29.06	28.92	29.33	29.84
Irrigation at 85% IWR +1½kg/ vine Hundz soil	0.84	0.87	0.89	0.89	3.033	3.167	3.390	3.383	29.08	28.95	29.19	29.98
Irrigation at 85% IWR +2kg/ vine Hundz soil	0.86	0.88	0.90	0.92	3.100	3.233	3.483	3.550	29.23	29.40	30.00	30.26
irrigation at 70% IW+ without Hundz soil	0.77	0.83	0.85	0.86	2.700	2.800	2.883	3.060	27.27	27.95	28.55	28.05
Irrigation at 70% IWR +½kg/vine Hundz soil	0.81	0.83	0.86	0.87	2.800	2.933	2.933	3.217	27.97	28.69	28.78	28.98
Irrigation at 70% IWR +1kg/ vine Hundz soil	0.82	0.84	0.87	0.88	2.850	3.000	3.033	3.283	28.44	28.73	29.26	29.78
Irrigation at 70% IWR +1½kg/ vine Hundz soil	0.83	0.85	0.87	0.89	2.950	3.133	3.333	3.333	29.06	28.81	29.93	29.98
Irrigation at 70 % IWR +2kg/ vine Hundz soil	0.84	0.87	0.89	0.90	3.050	3.200	3.450	3.517	29.05	29.37	29.99	30.19
L.S.D at 5%	**0.01**	**0.02**	**0.01**	**0.01**	**0.056**	**0.068**	**0.093**	**0.114**	**0.31**	**0.43**	**0.29**	**0.28**

Water relations parameters

Irrigation water apply

Results in Table 11 and figure1 clearly show that for the four considered years (2019, 2020, 2021, and 2022), seasonal irrigation water applied (IWA) reflects the variation in weather factors which the crop evapotranspiration calculated is based on it. The maximum value of IWA (5075 m^3/fed) was noted in the hotter season of 2020 followed by 2022 while minimum value (4496 m^3/fed) was recorded in 2019. These results ensure the importance of weather factors in irrigation application roles. On the other hand, the results showed also that, the monthly IWA was different from month to month within years, depending on weather parameters and tree age as well as crop canopy, in which maximum values were obtained in July, and the minimum values were shown in November.

Actual water consumptive use (Actual crop evapotranspiration (Eta))

Results installed in Table 12 showed the seasonal water consumptive use (m^3 fed^{-1}) as affected by irrigation treatments and hundz soil rates during the four seasons of 2019:2022 years. The actual water consumptive use represents the useful portion of irrigation water applied and ultimately in crop production. The obtained results illustrated that the seasonal water consumptive use values (m^3 fed^{-1}) were greatly affected by the water stress, where the lowest value of Eta was recorded at 70% IWR. The decreases in Eta reached to 22.1, 30.7, 20.7 and 20.2% for respective seasons as compared with 100%IWR (control) treatment.

On the other hand, it can be noticed that seasonal water consumptive use (m^3 fed^{-1}) was increased as the rate of hanzsoil increased under each irrigation treatment. Hence, the highest seasonal water consumptive use (m^3 fan^{-1}) was found when grapevines were treated with 2 or 1.5 kg hundz soil followed by1kg. On the opposite, the lowest seasonal water consumptive use (m^3 fan^{-1}) was noted for control (without hundz soil) under each irrigation level. The increases in seasonal water consumptive use due to high rate of hundz soilwere 12, 12.8, 18.8 and 14.1, % under 85% IWR in seasons 2019.2020,2021 and 2022 respectively, similar values for 70% IWR reach to 14.4, 29.4, 26.1, and 21.7, % when compared with control (without hundz soil).

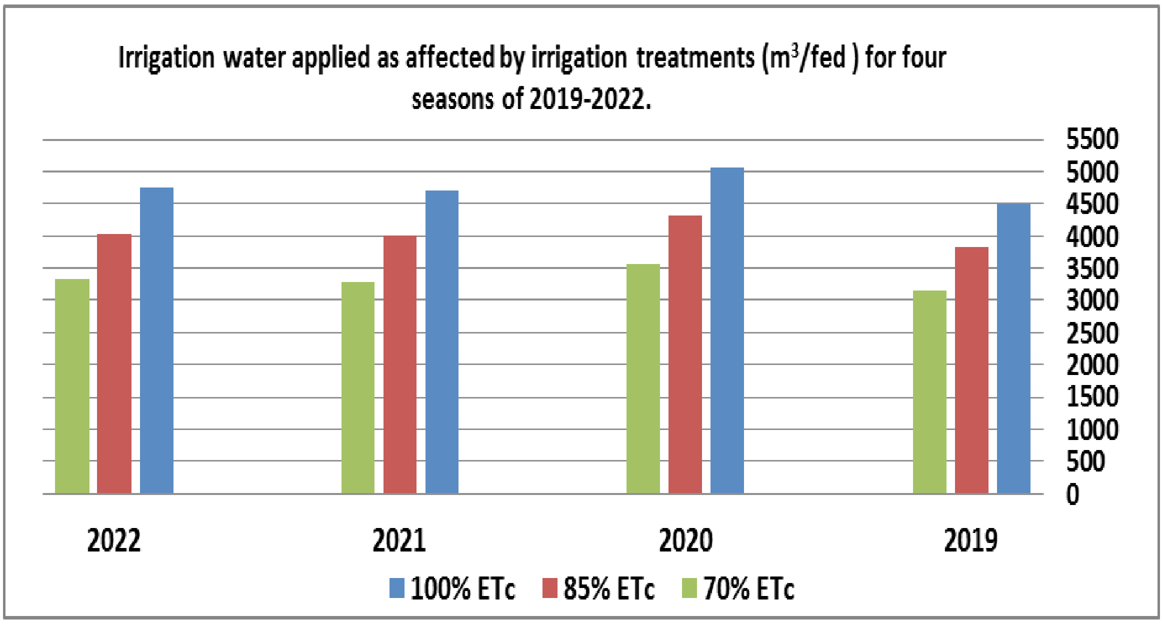

Fig. 1. Irrigation water applied as affected by irrigation treatments (m^3/fed) four seasons of 2019-2020

TABLE 11. Monthly water consumptive use (m^3/fed) as affected by irrigation levels under hundz soil rates of Flame seedless grapevines during 2019, 2020, 2021, and 2022

Seasons	2019			2020			2021			2022		
Months	100% ETc	85% ETc	70% ETc	100% ETc	85% ETc	70% ETc	100% ETc	85% ETc	70% ETc	100% ETc	85% ETc	70% ETc
March	19	16	13	19	16	14	18	15	12	20	17	14
April	81	69	57	78	66	55	68	58	48	69	59	48
May	111	95	78	123	105	86	111	94	78	110	94	77
June	146	124	102	151	129	106	161	137	113	140	119	98
July	163	138	114	198	168	138	182	155	127	183	156	128
August	149	127	105	177	150	124	161	137	113	167	142	117
September	117	99	82	142	121	100	123	105	86	130	110	91
October	88	75	61	99	84	69	89	76	62	101	86	71
November	18	15	12	20	17	14	19	16	13	21	18	15
Seasonal Etc (mm)	892	758	624	1007	856	706	932	793	652	941	801	659
Seasonal Etc(m^3/fed)	3746	3184	2621	4229	3595	2965	3914	3331	2738	3952	3364	2768
Seasonal IWA(m^3/fed)	4496	3820	3145	5075	4314	3558	4697	3997	3286	4743	4037	3321

TABLE 12. Effect of irrigation levels with hundz soil substance on WCU, IWP, and WUE of Flame seedless grapevines during 2019, 2020, 2021, and 2022

Treatments	WCU				IWP				WUE			
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
Irrigation at 100% (control)	3323	3911	3405	3395	2.16	2.05	2.37	2.41	2.95	2.68	3.30	3.40
Irrigation at 85% IWR+ without Hundz soil	2903	3207	2961	3004	2.92	2.63	2.89	2.93	3.88	3.57	3.94	3.92
Irrigation at 85% IWR +½kg/vine Hundz soil	2937	3270	3053	3096	3.06	2.78	3.05	3.05	3.82	3.60	3.91	3.88
Irrigation at 85% IWR +1kg/ vine Hundz soil	3057	3367	3275	3294	3.08	2.74	3.07	3.11	3.88	3.59	3.89	3.91
Irrigation at 85% IWR +1½kg/ vine Hundz soil	3265	3603	3487	3526	3.12	2.81	3.10	3.17	3.90	3.64	4.00	3.92
Irrigation at 85% IWR +2kg/ vine Hundz soil	3289	3690	3627	3531	3.32	2.97	3.28	3.24	3.99	3.71	4.04	4.00
irrigation at 70% IW+ without Hundz soil	2591	2810	2700	2710	3.32	3.13	3.48	3.57	4.07	4.00	4.28	4.42
Irrigation at 70% IWR +½kg/vine Hundz soil	2617	2763	2835	2821	3.48	3.36	3.69	3.68	4.23	4.40	4.28	4.45
Irrigation at 70% IWR +1kg/ vine Hundz soil	2705	3018	2966	3038	3.62	3.47	3.78	3.74	4.24	4.43	4.30	4.47
Irrigation at 70% IWR +1½kg/ vine Hundz soil	2894	3301	3197	3275	3.78	3.50	3.80	3.82	4.30	4.45	4.31	4.52
Irrigation at 70 % IWR +2kg/ vine Hundz soil	2965	3508	3405	3299	3.93	3.55	3.90	3.94	4.35	4.38	4.31	4.62

Irrigation water productivity (IWP)

The irrigation water productivity has been used to evaluate producing yield per unit of irrigation water. Values of irrigation water productivity (IWP) as affected by irrigation treatment in four growing seasons are listed in Table 12 in which the highest values were showed under irrigation at 70% IWR in the four seasons, while the lowest values were recorded with 100% IWR. Results indicate also, that IWP values tended to steadiness under the lower rate of hundz soil, especially at 85% IWR. But, IWP increased with increasing appellation rate of hundz soil rate to 2kg /tree and under deficit irrigation (70% IWR).

Water Use Efficiency (WUE)

Water use efficiency is expressed as kg fruit/ m^3 of water consumed. It has been used to evaluate producing yield per unit of water consumed by the crops. Data in Table 12 reveal that a positive effect was found on water use efficiency due to irrigation levels in all seasons of study. The highest values of WUE were obtained under irrigation at 70% IWR for all growing seasons of 2019 to 2022, respectively. While the lowest value resulted with control (100% IWR) for respective seasons. It is clear that all season results revealed that decreasing IWR rate lead to increasing WUE to a maximum value. It could be stated that adopting deficit irrigation at an acceptable level could reduce the water consumed by the plant due to shortening water losses if associated with the appropriate yield production of the crop will increase water use efficiency. Moreover, results showed that although the application of hundz soil conditioner increased grapevine water use, the WUE values showed a slight increase under low rates of hundz soil (1/2 and1kg/vine and, the best results were noted with 2 kg/vin compounded with 70%IWR irrigation treatment in all seasons, but greatly improved these recorded in WUE due to applying 2 kg hundz soil when compared whit control (100%IWR). Hence, the increases reached to 47.5, 63.2, 30.5, and 35.8 % in 2019, 2020, 2021 and 2022 seasons respectively. This may be due to continues availably of water to be absorbed by the plant as well as nutrient uptake which avoids water stress under 70%IWR, which reflects the importance of conditioner hundz-soil in saving more soil water around root zoon from losses by ether evaporation or drainage and increase water holding capacity in sandy soils. (Ezzat et al., 2011) stated that applying soil amendments, to sandy soil improves the soil's physical properties and decreases water loss by drainage leading to rationalization of irrigation water, and increasing irrigation water efficiency

Costs and net profit /feddan

It is evident from the data achieved in Table 13 that adding Flame seedless grapevines with hundz soil substances plus an irrigation level at70 and 85% IWR gave the best net profit/ feddan as compared with Irrigation at 100% (control). Additionally, the treatment of irrigation at 85% IWR +2kg per vine hundz soil gave the highest values in net profit/ feddan as compared with other treatments which recorded 10480 (L E) followed by an irrigation at 70% IWR + hundz soil 2kg per vine which recorded 10360 (L E)over control as average four seasons

Discussion

Hundz soil is a natural soil conditioner that is made out of dry compressed cellulose and recycles agricultural material, has a balanced pH of 6.8-7.2, is shaped like grains and ranges in size (0.2-2.0mm), is able to penetrate sand grains to create a new media that is perfect for growing plants, and has a water holding capacity that will change sandy soil's water capacity and does not absorb heat, which significantly reduces water evaporation. Hundzsoil absorbs water for a longer period of time than conventional soil, allowing plants to grow strong roots and contains 80% organic matter and is capable of holding water 3 times as much as any soil conditioner and product is slow release and can last up to two growing seasons Hundz soil keeps the water and moisture in the soil, help the roots and the plant to grow, improves soil's structure. Omer, et al (2020)

The obtained results suggested generally that improving the morphological characteristics of Flame Seedless grapes after application of hundz soil may be due to increasing cation exchange capacity and mineral nutrients, which in turn encouraged bud behavior , vegetative growth , yield ,physical and chemical characteristics of berries, according to Eman (2011) who showed that gradual increment of hundz soil application up resulted in a significant increases of vegetative growth, compared to control. The results showed generally that the application of hundz soil at rereflected considerable rising impacts on the mean values of the previous characters than other treatments in all four years with regard to the primary effects of hundz soil on the aforementioned parameters. The combination of subsurface irrigation and Hundz soil showed the maximum mean values of growth characteristics compared subsurface irrigation alone during both seasons, Omer, et al (2020). Hundz soil has a high cation exchange capacity, and thereby, it will affect the soil nutritional capacity and the supply of nutrients to plants. Also, it has a high water absorbing capacity, which will affect positively the yield (Wafaa El-Etr, 2001). The increment in yield per vine and chemical characteristics of the berries, could be attributed to an enhanced effect on berry weight as a result of enhanced bud behavior of the vines (Table 4) and enhanced vegetative growth parameters of Flame Seedless grapes (Table 5) as a result of using hundz of soil plus an irrigation level.

These results are in correspondence with those obtained by Ali et al. (2007), who found that the yield of peanut and carrot increased significantly by natural amendment application compared to non treatednon-treated ones. Fitzpatrick, (1986) found that humus (soil conditioners) is capable of absorbing large quantities of water; thus increasing the water holding capacity of the soil and therefore crop production. Concerning the main effects of application of hundz soil on fruit chemical composition, the results reflected that hundz soil at the highest rate increased fruit juice TSS and anthocyanin in both seasons.

With regard to the water requirement levels, results showed that decreasing the irrigation Water application by 15% and irrigating at 851% IWR (I2) led to maximizing all the characteristics of the crop, including vegetative characteristics and fruit yield. may be this due to the high efficiency of drip irrigation system, scheduling irrigation (continuity of water availably, even in smaller quantities), and increased distribution of the roots deeper in the soil which increases the root mass which provides more absorption of water as well as nutrients. The best value of water use efficiency WUE was obtained with the water deficit treatment (70%IWR).

These outcomes agree with those that were already reached by Genaidy et al (2016) who stated that IWUE was significantly increased with the decrease in irrigation amounts. In addition, Wei et al. (2017) and Rabeh, et al. (2022) stated that grapevines irrigated at 75% of their water requirements improved the water use efficiency as compared with those irrigated at 100% or 50% of their water requirements. More improvement in WUE was noticed with the addition of 2kg/vine hundz soil under irrigation at 70% IWR, which

TABLE 13. Effect of irrigation levels with hundz soil substance on costs and net profit /feddan of Flame seedless grapevines as average four seasons (2019, 2020, 2021, and 2022).

Treatments	Costs of *cultural practices / fed. (L.E.) without Irrigation	Costs of Hundz soil / fed. (L.E.)	Costs of Irrigation/ fed. (L.E.)	Treatments costs/fed. (L.E.)	Total costs / fed. (L.E.)	/Yield .fed Ton	Total production /fed. (L.E.)	Net profit / fed. (L.E.)	Net profit / fed. over control (L.E.)
Irrigation at 100% (control)	30000	0	4000	4000	34000	10.34	62040	28040	0
Irrigation at 85% IWR+ without Hundz soil	30000	0	3400	3400	33400	10.84	65040	31640	3600
Irrigation at 85% IWR +½kg/vine Hundz soil	30000	245	3400	3645	33645	11.37	68220	34575	6535
Irrigation at 85% IWR +1kg/ vine Hundz soil	30000	490	3400	3890	33890	11.457	68742	34852	6812
Irrigation at 85% IWR +1½kg/ vine Hundz soil	30000	735	3400	4135	34135	11.66	69960	35825	7785
Irrigation at 85% IWR +2kg/ vine Hundz soil	30000	980	3400	4380	34380	12.15	72900	38520	10480
irrigation at 70% IW+ without Hundz soil	30000	0	2800	2800	32800	10.78	64680	31880	3840
Irrigation at 70% IWR +½kg/vine Hundz soil	30000	245	2800	3045	33045	11.30	67800	34755	6715
Irrigation at 70% IWR +1kg/ vine Hundz soil	30000	490	2800	3290	33290	11.56	69360	36070	8030
Irrigation at 70% IWR +1½kg/ vine Hundz soil	30000	735	2800	3535	33535	11.74	70440	36905	8865
Irrigation at 70 % IWR +2kg/ vine Hundz soil	30000	980	2800	3780	33780	12.03	72180	38400	10360

* Cultural practices such as (Fertilizers, Pesticides, fungicides and Labour)

- Costs of Hundz soil (1kg) 0.70 (L.E.)
- One feddan =700 vines
- Costs of Irrigation at 100%=4000 (L.E.) / feddan.
- Costs of Irrigation at 85%=3400 (L.E.) / feddan.
- Costs of Irrigation at 70%=2800 (L.E.) / feddan.
- Price one ton from yield = 6000 (L .E.)

reflects an increase in the ability of soil to retain water by adding natural soil conditioners such as hundz soil, The results is in good agreement whit those recorded whit (Ezzat et al., 2011) who stated that applying soil amendments, to sandy soil improves the soil's physical properties and decreases water loss by drainage leading to rationalization of irrigation water, and increasing irrigation water efficiency

The present trial results indicate the possibility of providing 15-20% of the water ration for grapes without a decrease in the productivity of the feddan, with more quality characteristics of the fruits, provided that the soil characteristics are improved and its water-holding capacity is increased by adding natural soil conditioners such as hundz soil

Conclusion

It can be recommended that the best results were obtained when adding hundz soil 2 kg/vine under drip irrigation lines in January, plus an irrigation level at 85% IWR on bud behavior, vegetative growth, yield, fruit quality, pruning wood weight, total carbohydrates in canes and with possibility of providing 15-20% of the water ration for grapes without a decrease in the productivity of the feddan of Flame seedless grapevines.

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Conflicts of interest

The authors declare that there are no conflicts of interest related to the publication of this study.

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زيادة كفاءة مياه الرى المستخدم باضافة هانزسويل لتحسين النمو الخضرى وجوده الثمار والمحصول لكرمات العنب الفليم سيدلس تحت ظروف الاجهاد المائى

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أجريت هذه التجربة خلال اربع مواسم متتالية (2019 و 2020 و 2021 و 2022) على كرمات العنب الفليم سيدلس في منطقة الخطاطبة بمحافظة المنوفية ، مصر. لدراسة تأثير كفاءة استخدام مياه الري تحت نظام الري بالتنقيط مع اضافة مادةالهانزسويل للتربة لتحسين النمو الخضري وجودة الثمار ومحصول العنب لصنف الفليم سيدلس. ، تم اختيار كروم عمرها سبع سنوات منزرعة على مسافة 2X3 متر، كما تم تقليم الكرمات تقليما دابريًا خلال شهر ديسمبر ومرباة تحت نظام التدعيم بالتكاعيب الأسبانية.

تهدف التجربة لدراسة اربع مستويات من محسن التربه هانز سويل (0.5 ، 1 ، 1.5 و 2 كجم / كرمة) تحت مستويات الري عند 70 ، 85 و 100٪ من المقننن المائي للعنب و تمت معاملة محسن التربه هانزسويل على التربة تحت خطوط الري بالتنقيط في يناير من كل عام.

أظهرت النتائج أن إضافة محسن التربه هانزسويل 2 كجم / كرمة مع مستوى الري عند 85٪ من الاحتياجات المائية كانت فعالة في تحسين تفتح البراعم ، ونسبة خصوبة البراعم ، ومعامل الاثمار،وطول الافرع ، وعدد الأوراق على الفرع ، ومساحة الأوراق ، الأنثوسيانين الكلي فى قشرة الثمار وكذلك تحسين المحصول للكرمة ، وزن العنقود ، وزن االحبة ، محتوى المواد الصلبة من العصير، مع تقليل الحموضة القابلة للمعايرة في الثمار مقارنة بباقى المعاملات مما ادي الي توفير حوالي 15٪ من المياه لتحقيق نفس المحصول وجودة الثمار ، وفقًا لتوافر المياه ، تحت نظام الري بالتنقيط , بينما ادي الري بـ 70٪ من المقنن المائي و اضافة 2 كجم / كرمة هانز سول الي تحسين كفاءة استخدام المياه (WUE).

الكلمات الدالة: عنب ، الفليم سيدلس ، النمو الخضرى ، المحصول ، جودة الثمار، هانزسويل ، الرى.