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EVALUATION OF SOME GRAPE ROOTSTOCKS FOR RESISTANCE TO ROOT– KNOT NEMATODE (*MELOIDOGYNE INCOGNITA*) AND REFLECTION ON VEGETATIVE, CHEMICAL CHARACTERS, ROOT DENSITY AND DISTRIBUTION

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ABSTRACT: This investigation was carried out in two successive seasons (2021 and 2022) on one – year – old six grape rootstocks: Freedom, Harmony, Salt Greek, Teleki, SO4 and Richter. These rootstocks were evaluated for resistance to different inoculum levels of *Meloidogyn incognita* i.e. 1000, 2000, 3000, 4000 and 5000 J_2 /pot. The different rootstocks were left out; plant, root and soil were examined at the end of the two seasons.

Results indicated the superiority of Harmony and Freedom rootstocks than the other four rootstocks. These rootstocks are characterized by: vigorous vegetative growth as indexed by plant height, number of leaves / plant, fresh and dry weights of plant aerial portion, total leaf area and total chlorophyll content, also larger root system density with longest and better fine, medium and large roots distribution than other rootstocks. Moreover, the rootstocks had higher leaf petioles content of N, P and K.

Also data of nematode parameters showed that, number of nematode in soil, number of females, egg-masses/ root system and eggs / eggs-mass, rate of build-up and numbers of galls. Results revealed that all nematode parameters were significantly increased as the inoculum levels of nematode increased from 1000 to 5000 J_2. In addition, both Harmony and Freedom gave the lowest nematode population in soil and roots, rate of nematode build-up and number of galls/root (most resistant rootstocks), while, Salt Greek and Teleki were (moderately resistant). On the other hand, SO4 and Richter were the most susceptible rootstocks to *M. incognita*.

Generally, the six rootstocks could be discerningly arranged due to their resistance against root- knot nematode *M. incognita* and its reflection on vegetative growth, root density and distribution under this study conditions as follow: (Harmony & Freedom),(Salt Greek & Teleki) and finally (SO4& Richter). Accordingly, both rootstocks (Harmony& Freedom) can use for controlling root knot nematode *M. incognita* in Egypt.

Keywords: Grape rootstocks, *Meloidogyne incognita*, resistance, Harmony, Freedom, Salt Greek, Teleki, SO4, Richter and inoculum levels of nematodes.

INTRODUCTION

Grape is considered one of the most important fruit crops in Egypt as well as all over the world. The cultivated areas reached 1,873,580 fadden with a production of 1,683,968 tons (According to the annual statistics of the Ministry of Agricultural in 2020). This area is increasing rapidly as more desert areas are being planted every year either for local market or exportation. The major reason to use rootstocks lies in their resistance to some adverse conditions (Reynolds and Wordle, 2001) outlined major criteria for rootstocks choice in order of their importance as phylloxera resistance, nematode resistance, and adoptability to high soils, saline soils pH. Certain species of nematodes are the main cause of vine decline. Many species of these nematodes have been found on vine roots in Egypt (Riad,1974). Damage caused by root –

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knot nematodes *Meloidogyne* spp. in vineyards grown in Egypt's sandiest soils has become a major pest problem facing vineyard production. Most of the control of these parasites has been carried out with nematicides, but these chemicals are high toxic to mammalian and environment, so the introduction of rootstocks is becoming a good alternative. Low inoculation dose of 2000 nematode larvae / plant was decreased plant weight, root mass and leaf number (Akopyan *et al*., 1987).(Anwar and Van – Gundy, 1989 and 1992; Rubiano *et al*., 1995; Kesba 1999; Mckenry *et al.,* 2004 and Ola, 2007.

Mckenry *et al.* (2001) indicated that root & shoot length as well as growth weights of grapes were retarded by *M. incognita*. Sixteen screened cultivars of grape over a two–year period in the presence or absence of 10 different nematode populations. Populations of *Meloidogyne* spp. developed rapidly and cause damage. (Kesba, 2003) evaluated ten grape rootstocks against the nematode species, *Meloidogyne incognita, Meloidogyne javanica, Rotylenchulus reniformis* and *Tylenchulus semipentrans*. He cited that Harmony was resistant to four species and Harmony, San George and SO4 were resistant to *M. incognita*. (Mckenry *et al*., 2004) graded Dog Ridg, Freedom, Harmony, Teleki and Ramsey as susceptible hosts to *M. arenaria*, while Harmony was resistant to all other *Meloidogyne* spp.

The target of this study was to evaluate some grape rootstocks for their resistance to different inoculum levels of root-knot nematode (*Meloidogyne incognita*) and it' s reflection on vegetative growth, root density and root distribution, chemical content and organic substances.

MATERIALS AND METHODS

This investigation was carried out during two successive seasons of 2021 and 2022 under greenhouse conditions of the nematode Research Department; Plant Pathology Research Institute, Agric. Res. Giza. This study was aimed to evaluate the resistance of one-year-old six grape rootstocks, Freedom, Harmony, Salt Greek, Teleki, SO4 and Richter to different inoculum levels of root-knot nematode *(Meloidogyne incognita).*

Host susceptibility of some grape cultivars to different inoculum levels of the root-knot nematode; *Meloidogyne incognita*

Grape rootstocks were obtained from Horticulture Research Institute, Agricultural Research Center, Giza, Egypt and were examined for their relative susceptibility to the infestation of root-knot nematode; *M. incognita.* These rootstocks were Freedom, Harmony, Salt Greek, Teleki, SO4 and Richter. Seedlings of each rootstock were put in clay pots; each pot filled with steam sterilized sandy loamy soil (18% clay, 10% silt and 72% sand).

Each rootstock was inoculated with five different inoculum levels; 1000,2000,3000,4000 and 5000 newly hatched larvae of *M. incognita* around the roots one week after planting. Each rootstock replicated five times for each inoculum as well as five seedlings for each cultivar were kept without inoculation to serve as a check. All pots were arranged in completely randomized design, and kept under greenhouse conditions at 25-28^{o}C. All pots received similar horticultural treatments throughout the experimental period (two months) until the end of each season (2021 & 2022). The rootstocks were left out; plant roots and soil of each rootstock cultivar were examined.

The following parameters were evaluated

Shoot parameters & total chlorophyll content

At the end of each experimental season, plant height (cm), number of leaves / plant, fresh and dry weights of the plant aerial portion (g), total leaf area of each rootstock; average of leaf area (cm^2) (using a cl – 203 – laser Area meter made by CID, Inc. Vancouver, USA) X total number of leaves / plants), and total chlorophyll content of leaf was measured by using nondestructive Minolta chlorophyll meter SPAD 502 (Wood *et al*., 1992).

Root system measurements

At the end of each experimental season, the rootstocks were carefully taken from each pot and the whole plant was cut to two parts (the aerial portion and root system). The roots were

washed and sieving then root density was determined (fresh and dry weights of root system (g) as well as total number of roots / plant). Roots were classified into fine roots (less than 2 mm in diameter), medium roots (2-6 mm) and large roots (more than 6 mm) length was recorded for each sample (Bohm, 1979).

Chemical determination

At the end of seasons samples of leaf petioles were washed and dried at 70ºC for 48 hours. Dried samples were wet ashed using a concentrated H_2SO_4 and 30% H_2O_2 in the digested solution, nitrogen was determined by the steam distillation procedure using Velpmicrokjeldahl instrument, Potassium was determined by flame photometer whereas phosphorus was measured calorimetrically by a spectrophotometer (Champman and Pratt, 1961).

Nematode parameters

Number of juveniles/250 g. soil of the six different rootstocks i.e Freedom, Harmony, Salt Greek, Teleki, SO4 and Richter were determined according to (Franklin and Goodey, 1957). Roots of each rootstock were stained by acid fuchsin in lactophenol according to (Byrd *et al*., 1983), and examined for number of developmental stages and females / root. Eggs /egg mass of *M. incognita* were extracted by using sodium hypo-chlorite (NaOCI) method as described by (Husssey and Barker, 1973). In addition, the final nematode population (PF) and rate of *M. incognita* build-up (PF/PI) were calculated according to (Oostenbrink, 1966) as follows:-

Final nematode population (PF) =
(No. of egg masses X No. of eggs/egg masses+ No. of females + No. of developmental stages + No. of juveniles in soil/pot).

$$\text{Rate of build-up (RF)} = \frac{\text{Final population (PF)}}{\text{Initial population (PI)}}$$

Statistical analysis

The obtained data was statistically analyzed using complete randomized block split plot design with two factors. The main factor (plot) was rootstocks and the other factor (subplot) was the level of inoculation. Averages were compared using the new L.S.D. values at 5% level (Sendecor and Cochran, 1980).

RESULTS AND DISCUSSION

1-The effect of different inoculum levels of root -knot nematode on some vegetative growth parameters and total chlorophyll content:

Tables (1 & 2) and Figure (1) show the effect of different inoculum levels of root-knot nematode on six grape rootstocks and their reaction on some growth parameters, i. e. plant height, number of leaves / plant, fresh and dry weights of aerial portion, total average of leaf area and total chlorophyll content of leaf. Results showed a significant difference in growth parameters of tested rootstocks under study in both seasons. Harmony rootstock has the highest plant growth, highest number of leaves / plant, heaviest fresh and dry weights of aerial portion and higher leaf area than other rootstocks followed by Freedom, Salt Greek, Teleki, SO4 and Richter, respectively in both seasons.

The growth parameters of six rootstocks were significantly affected with different inoculation levels. Plant growth parameters gradually decreased with increasing the inoculum levels of nematodes from (1000 to 5000 J_2). However, the values were then decreased gradually by increasing inoculation level to reach the lowest values with Richter inoculated by 5000 J_2.

Results of total chlorophyll content of leaf revealed a trend similar to that of previously mentioned with growth parameters. The vigorous growth of Harmony and Freedom rootstocks can be attributed to their large root system as shown in (Tables, 3&4) and (Fig. 2&3), which in turn may uptake adequate amount of water and mineral nutrients via the roots. These results are agreement with Anwar (1986); Wachtel (1986); Akopyan, *et al.*, (1987); Anwar and Van Gundy (1989 and 1992); Rubiano *et al*., (1995); Walker (1997); Kesba (1999) and Ola (2007) as they mentioned that shoot length, shoots fresh and dry shoots weights were reduced by *M. incognita.*

Table (1): The effect of different inoculum levels of root-knot nematode on growth parameters of six grape rootstocks in 2021 season

Rootstocks (A)	inoculum levels (B)	Plant height(cm)	No. of leaves/ plant	F.W. of aerial portion (g)	D.W. of aerial portion (g)	Total leaf area (cm^2)	Total chlorophyll (mg/g F.W.)
Freedom	Control	93.3	153.2	26.13	24.00	5346.7	38.10
	1000	90.0	147.0	22.50	22.40	498.0	38.70
	2000	85.9	142.0	19.70	18.60	4659.9	34.50
	3000	81.7	138.4	17.50	15.20	4203.2	31.80
	4000	75.5	135.0	16.00	13.50	3833.7	28.50
	5000	68.4	131.0	15.20	12.30	3537.0	26.70
Mean (A)		82.5	141.10	19.51	17.67	4426.4	3305
Harmony	Control	97.0	153.3	32.70	25.50	5978.7	40.43
	1000	94.6	152.0	32.20	25.10	5807.6	40.20
	2000	91.5	150.4	30.70	24.80	5790.4	40.00
	3000	87.2	148.9	29.60	24.20	5658.2	39.90
	4000	82.3	147.5	28.30	23.70	5546.0	39.80
	5000	77.5	146.0	27.60	23.20	5431.2	39.50
Mean (A)		88.4	149.7	30.18	24.42	5717.0	39.97
Salt Greek	Control	96.0	160.0	34.07	27.50	6400.0	42.47
	1000	89.1	127.1	27.80	19.70	4473.0	35.00
	2000	82.9	124.3	20.00	17.50	3890.6	33.13
	3000	74.9	122.0	14.20	15.00	3440.4	30.00
	4000	67.4	119.0	9.000	13.10	3022.6	28.20
	5000	58.5	117.0	5.500	11.90	2679.3	25.00
Mean (A)		78.0	128.23	18.43	17.45	3984.5	32.30
Teleki	Control	88.67	106.0	25.30	20.30	2968.0	31.63
	1000	82.56	99.00	19.00	6.50	2484.9	27.70
	2000	75.4	93.00	14.50	13.30	2101.8	24.50
	3000	67.9	88.00	10.40	11.10	1760.0	21.57
	4000	59.9	84.00	7.500	9.200	1554.0	19.60
	5000	50.0	81.00	5.000	8.067	1409.4	17.50
Mean (A)		70.7	91.83	13.62	13.08	2046.4	23.75
SO4	Control	83.5	118.0	21.83	18.90	3540.0	35.00
	1000	74.6	109.0	13.90	12.70	2343.5	29.00
	2000	64.5	101.0	10.70	7.800	1626.1	24.00
	3000	51.3	95.00	7.500	3.900	1159.0	18.90
	4000	37.2	90.00	5.067	2.800	837.0	14.20
	5000	20.0	86.00	4.233	1.600	645.0	11.00
Mean (A)		55.2	99.83	10.54	7.950	1691.8	22.02
Richter	Control	73.0	115.0	19.77	15.00	2944.0	33.00
	1000	65.0	106.3	11.50	10.00	1775.2	27.00
	2000	55.9	98.20	9.400	6.200	1227.5	21.20
	3000	46.7	92.50	7.000	3.300	869.5	16.00
	4000	35.5	88.00	5.700	2.100	572.0	12.20
	5000	21.0	84.00	4.500	1.000	356.4	9.000
Mean (A)		49.5	97.33	9.644	6.267	1295.8	19.78
Table (B)	Control	88.6	130.6	26.63	21.87	4465.1	36.77
	1000	82.6	124.4	21.15	12.73	3720.3	32.93
	2000	75.9	119.0	17.50	14.70	3216.0	29.56
	3000	68.3	114.7	14.37	12.12	2848.4	26.36
	4000	59.6	111.2	11.93	10.73	2560.9	23.80
	5000	49.2	108.2	10.34	9.078	2348.1	21.45
New L.S.D.	A	3.4	0.4939	0.1501	0.05946	0.2144	0.2592
at 5%	B	3.4	0.4939	0.1501	0.05946	0.2144	0.2592
Level	A x B	8.3	1.210	0.3678	0.1457	0.5252	0.6349

F.W. = fresh weight

D.W. = Dry weight

Table (2): The effect of different inoculum levels of root-knot nematode on growth parameters of six grape rootstocks in 2022 season

Rootstocks (A)	Inoculums levels (B)	Plant height (cm)	No. of leaves/plant	F.W. of aerial portion (g)	D.W. of aerial portion (g)	Total leaf area (cm^2)	Total chlorophyll (mg/g F.W.)
Freedom	Control	94.5	145.0	25.20	18.70	5727.5	39.23
	1000	91.4	141.0	22.00	15.80	5358.0	37.20
	2000	87.2	138.0	19.30	12.90	5050.8	35.50
	3000	83.1	135.0	16.70	10.40	4765.5	34.00
	4000	77.5	132.0	14.30	83.00	4575.7	13.13
	5000	70.4	130.0	12.50	6.500	4381.0	30.40
Mean (A)		84.0	137.0	18.33	12.10	4976.4	34.58
Harmony	Control	97.2	154.0	32.50	17.00	6853.0	43.50
	1000	95.4	153.0	31.70	16.60	6517.8	42.30
	2000	92.0	151.0	31.00	16.27	6191.0	41.20
	3000	87.8	150.3	30.60	15.90	6027.0	40.30
	4000	83.3	148.0	30.40	15.70	5831.2	39.60
	5000	78.2	147.0	30.10	15.60	5733.0	39.00
Mean (A)		88.9	150.4	31.05	16.18	6192.2	40.98
Salt Greek	Control	95.0	156.0	31.53	19.33	7020.0	40.67
	1000	88.3	147.0	23.50	15.20	5880.0	36.80
	2000	81.2	137.0	19.20	12.00	5115.0	33.00
	3000	73.7	132.0	14.50	10.43	4356.0	30.13
	4000	65.6	128.0	10.60	7.000	3980.8	27.60
	5000	56.4	124.0	7.367	6.000	3633.2	25.00
Mean (A)		76.7	137.4	17.78	11.66	4997.5	32.20
Teleki	Control	88.0	100.0	20.60	13.30	3860.0	36.90
	1000	82.4	93.10	16.60	10.20	3277.1	34.10
	2000	75.0	87.50	13.50	7.600	2931.3	31.60
	3000	67.4	82.00	11.60	5.100	2542.0	29.20
	4000	59.5	78.40	9.800	4.000	2265.8	27.40
	5000	49.9	75.00	8.300	3.000	1987.5	25.00
Mean (A)		70.4	86.00	13.40	7.20	2810.6	30.70
SO4	Control	79.0	115.0	46.70	10.10	3473.0	30.50
	1000	70.2	106.2	17.50	7.000	2697.5	25.60
	2000	60.3	97.00	12.40	4.933	2066.1	21.50
	3000	48.1	90.00	9.200	2.900	1620.0	18.10
	4000	34.5	84.00	6.300	1.700	1386.0	15.70
	5000	18.0	79.00	4.100	0.8000	1137.6	13.90
Mean (A)		51.7	95.20	12.70	4.572	2063.4	20.88
Richter	Control	75.7	118.0	21.30	9.000	2714.0	35.20
	1000	67.9	109.0	13.60	6.500	2103.7	29.43
	2000	59.1	101.0	9.500	4.000	1555.4	24.20
	3000	49.8	94.00	6.300	2.200	1184.4	20.30
	4000	38.6	88.00	4.600	0.6000	862.4	17.00
	5000	25.0	83.00	2.900	0.3000	738.7	14.16
Mean (A)		52.7	98.83	9.700	3.767	1526.4	23.37
Table (B)	Control	88.2	131.3	26.31	14.57	4941.3	37.67
	1000	82.6	124.9	20.82	11.88	4305.7	34.24
	2000	75.8	118.7	17.48	9.617	3818.3	31.17
	3000	68.3	113.9	14.82	7.822	3415.8	28.67
	4000	59.8	109.9	12.67	6.217	3150.3	26.11
	5000	49.7	106.3	10.88	5.533	2935.2	24.57
New L.S.D.	A	3.9	0.5458	0.08919	0.2332	1.203	0.2102
at 5%	B	3.9	0.5458	0.08919	0.2332	1.203	0.2102
Level	A x B	9.6	1.337	0.2185	0.5711	2.946	0.5150

F.W. = fresh weight

D.W. = Dry weight

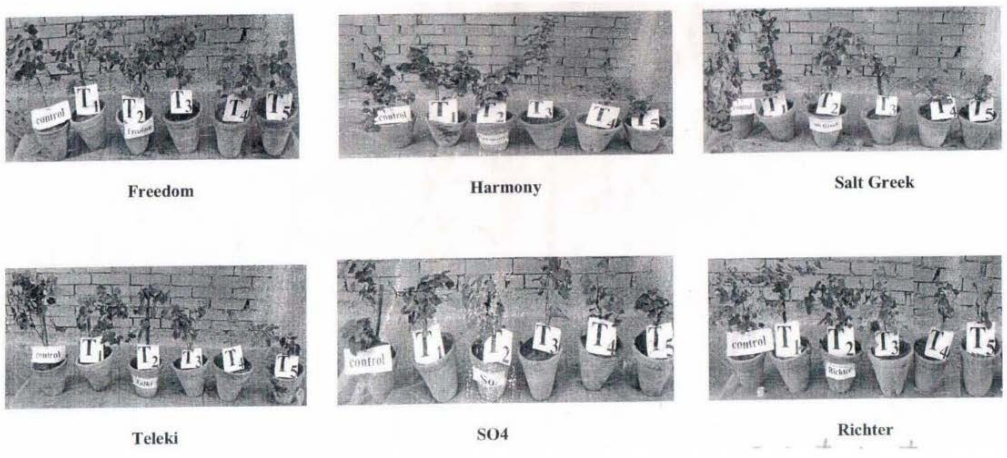

Fig.(1): Evaluation of six different grape rootstocks for resistance to root-knot nematode (*Meloidogyne incognita)*

Control: without nematode T1: 1000 J2/pot T2: 2000 J2/pot
T3: 3000 J2/pot T4: 4000 J2/pot T5: 5000 J2/pot

The effect of nematode injury on leaf photosynthetic pigments might be due to the lower ability of injured roots to absorb enough quantities of such elements as nitrogen, zinc, iron and magnesium, necessary for pigments synthesis.

Literature reports on the effect of nematode inoculum on leaf pigments are very rare. However, the obtained results agree with Gehan (2004). On the other hand, the obtained results disagree with Melakeberhan and Ferris (1989) working on Colom bard grapevines inoculated with *M. incognita* at 0.0 to 8000, they declared that leaf pigments were not affected by the level of inoculation.

Root system measurements

Root density

Data concerning root density (fresh and dry weights of root system as well as total number of roots / plant) presented in Table (3). Results showed that, there were significant differences between the six different rootstocks at two seasons of investigation. However Harmony recorded higher fresh and dry root weights and total number of roots / plant followed by Freedom.

On the other hand, Richter rootstock produced the least fresh & dry roots weights and total number of roots. Salt Greek and Teleki are intermediate rootstocks. All tested nematode inoculation levels significantly decreased root density especially at high inoculum level (4000 & 5000 J_2) compared with control plants which showed the highest values of these measurements.

The interaction rootstocks X inoculation levels was significant in both seasons. However, the upper most values were always obtained by (Salt Greek X control) dissentingly, followed by (Harmony X control and Harmony X 1000 J_2). The lower most values resulted from (Richter X 4000 & 5000 J_2).

Root distribution (root length)

Concerning the evaluation carried out on root system distribution (root length) of fine roots (root less than 2 mm in diameter), medium roots (roots 2-6 mm in diameter) and large roots (roots more than 6 mm in diameter) of the studied rootstocks under infection level and their interaction are presented in Fig. (2 & 3). Data revealed that, the highest length of fine roots was obtained by Harmony and Freedom rootstocks in the first season, while in the second season the longest fine roots obtained by Harmony rootstocks only, followed by Freedom, while Salt Greek and Teleki gave intermediate values in this respect. On the other hand, Richter and SO4 had the least corresponding values in both seasons. The Harmony rootstock produced the longest medium and large roots followed by Freedom rootstock while, Salt Greek and Teleki rootstocks were intermediate whereas, SO4 and Richter produced the shortest medium and large roots in both seasons of this study.

Table (3): Root density as affected by different grape rootstocks and inoculums levels of root-knot nematode in 2021 and 2022 season.

Rootstocks (A)	Inoculums levels (B)	F.W. of root/ plant (g)		D.W. of root/ plant (g)		Total No. of root/ plant	
		2021	2022	2021	2022	2021	2022
Freedom	Control	18.60	18.70	10.20	12.47	140.0	145.0
	1000	15.03	17.60	8.733	11.27	125.0	129.0
	2000	14.50	16.50	8.30	10.30	115.0	118.0
	3000	11.30	15.70	6.40	9.200	109.0	111.0
	4000	.200	14.90	4.50	8.800	105.0	106.0
	5000	6.00	13.20	3.40	7.900	95.00	92.00
Mean (A)		12.27	16.10	6.92	9.989	114.8	116.8
Harmony	Control	21.83	32.23	14.27	18.93	150.0	156.0
	1000	21.60	31.90	12.53	18.50	138.0	145.0
	2000	21.50	31.70	12.17	18.20	129.0	141.0
	3000	21.37	31.60	11.90	18.00	124.0	138.0
	4000	21.20	31.40	11.67	17.90	120.0	135.0
	5000	21.10	31.00	11.40	17.50	112.0	130.0
Mean (A)		21.43	31.64	12.32	18.17	128.8	140.8
Salt Greek	Control	23.53	29.30	13.30	15.00	126.0	138.0
	1000	12.00	22.27	9.20	11.00	108.0	119.0
	2000	10.10	16.20	6.40	8.400	96.00	106.0
	3000	8.20	12.00	4.94	6.600	88.00	99.00
	4000	6.70	9.000	3.90	5.000	82.00	94.00
	5000	5.300	6.900	2.80	4.100	74.00	88.00
Mean (A)		10.97	15.94	6.76	8.350	95.67	107.3
Teleki	Control	15.27	20.50	13.20	12.00	120.0	140.0
	1000	11.30	15.30	2.267	9.100	105.0	124.0
	2000	8.233	11.50	6.03	7.200	95.00	113.0
	3000	5.100	8.600	4.10	6.000	86.00	103.0
	4000	3.400	6.300	2.20	4.900	79.00	95.00
	5000	2.200	4.900	1.40	3.000	65.00	87.00
Mean (A)		7.583	11.18	5.70	7.033	91.67	110.3
SO4	Control	15.50	16.17	9.760	9.167	105.0	120.0
	1000	8.600	10.07	4.667	6.200	84.00	98.00
	2000	3.400	5.900	2.067	4.400	70.00	83.00
	3000	1.500	4.500	0.9400	3.500	60.00	72.00
	4000	0.6000	3.033	0.6000	2.800	51.00	61.00
	5000	0.4000	2.833	0.4000	1.500	44.00	54.00
Mean (A)		5.000	7.083	3.072	4.594	69.00	81.33
Richter	Control	8.900	16.50	6.667	8.367	96.00	110.0
	1000	4.500	9.267	3.000	4.500	75.00	89.00
	2000	2.500	4.180	1.000	3.000	61.00	73.00
	3000	1.000	2.800	0.8000	1.900	50.67	63.00
	4000	0.8000	2.000	0.4000	1.100	44.00	55.00
	5000	0.5000	1.500	0.3000	0.9000	35.00	47.00
Mean (A)		3.033	6.041	2.028	3.294	60.28	72.83
Table (B)	Control	16.68	22.23	10.99	12.66	122.8	134.8
	1000	12.77	17.73	7.811	10.09	105.8	117.3
	2000	10.04	14.33	5.994	8.583	94.33	105.7
	3000	8.078	12.53	4.847	7.533	86.28	97.67
	4000	6.817	11.11	3.878	6.750	80.17	91.00
	5000	5.917	10.06	3.283	5.817	70.83	83.00
New L.S.D.	A	0.1279	0.1313	0.05562	0.1313	1.080	0.5413
at 5%	B	0.1279	0.1313	0.05562	0.1313	1.080	0.5413
Level	A x B	0.3132	0.3216	0.1362	0.3216	2.644	1.326

F.W. = fresh weight

D.W. Dry weight

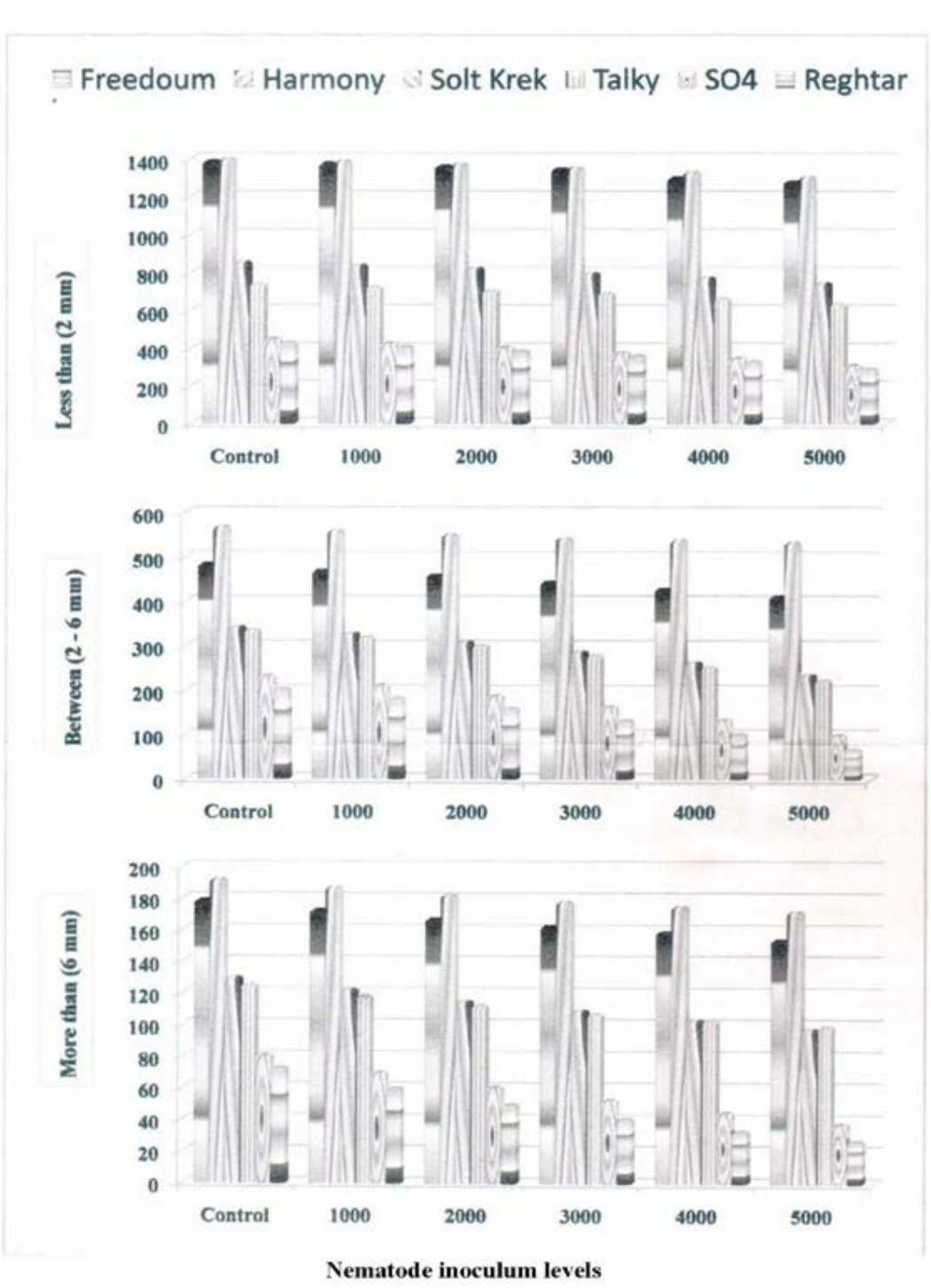

Fig.(2): Root length of different rootstocks as affected by different nematode inoculum levels in 2021 season

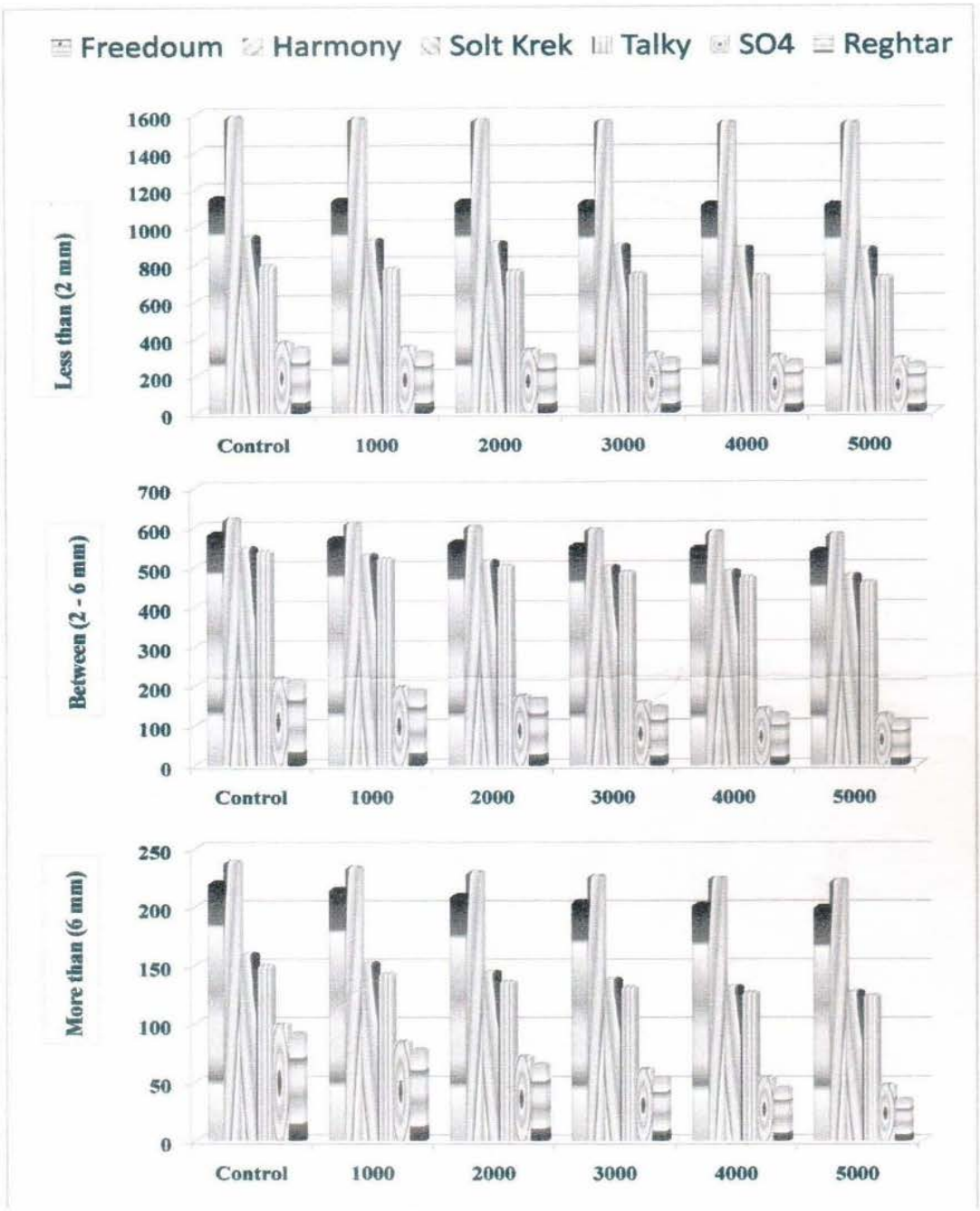

Fig.(3): Root length of different rootstocks as affected by different nematode inoculum levels in 2022 season

The obtained data revealed that the length of fine, medium and large roots / plant were significantly affected by the tested inoculation levels. The highest values were recorded by control plants, and then decreased gradually by increasing inoculation level. The interaction rootstocks X inoculation levels was significant in both seasons. The longest fine roots were obtained by (Harmony & Freedom X control and Harmony & Freedom X 1000 J_2) in the first season while in the second season the longest fine roots were obtained by (Harmony X control) only followed by (Harmony X 1000 J_2 and Harmony X 2000 J_2). Medium roots and larger roots revealed a trend similar to that of the previously mentioned with fine roots. The lowest values of this estimate resulted from (Richter X 5000 J_2). Based on the above mentioned root results, the six tested rootstocks could be discerningly arranged due to their root density and distribution as follow: Harmony, Freedom, Salt Greek, Teleki, SO4 and Richter. These results held true for both seasons.

These results might be due to the higher nematode resistance of Harmony and Freedom rootstocks compared to the other rootstocks and /or to the positive relation between vegetative growth and depth of root system in soil. These results in this connection are in agreement with those of Chitambar and Raski (1984) as they found that with Harmony rootstock, the numbers of nematode continued to increase with all inoculation levels, but the root weight was reduced only at the inoculum level 1000 after 12 months from inoculation with *M. incognita*. Also, Anwar (1986); Akopyan *et al.,* (1987) and Pieterse & Meyer (1987) found significant decreases in plant weight root mass and root growth even at low inoculation dose of 2000 larvae of *M. incognita*/plant.

Chemical determination

Mineral determinations

Data concerning nitrogen, phosphorus and potassium content of leaves are presented in Table (4). The highest values in both seasons belonged to leaves on Harmony rootstock followed by Freedom, and then came on Salt Greek and Teleki root stocks intermediate. The least values in this respect also belonged to leaves on SO4 and Richter rootstocks. The upper most N, P and K percentage always came from control plants. However, in most cases mineral content was gradually decreased as inoculums levels increased to reach lowermost values with the highest tested inoculation level (5000 J_2) in both seasons of investigation. The interaction between rootstocks and inoculation levels was significant in both seasons. The highest values was obtained from (control of Harmony), followed by (Harmony X 1000 J_2). On the other hand, (Richter X 5000 J_2) produced the least values. This result might be due to higher potential vigor and / or to the higher nematode resistance of Harmony and Freedom compared to other rootstocks.

Nematode parameters

Data in Table (5) season 2021 showed that nematode population of *M. incognita* in both soil and roots of grape rootstocks indicated significant effect by using the different nematode inoculums levels from 1000 to 5000 J_2. Nematode population in both soil and root revealed different degrees in resistance of grape rootstocks to root-knot nematode; *M. incognita*.

Results of two seasons, revealed that number of galls, developmental stages, females, egg masses/ root system, eggs/egg mass as well as numbers of larvae in 250 g soil were significantly increased as the increase of the nematodes inoculum levels from 1000 to 5000 J_2. In addition, both Harmony and Freedom were the most resistant grape rootstocks, while Salt Greek and Teleki were moderately resistant. On the other hand, SO4 and Richter were the most susceptible rootstocks to *M. incognita*. All grape rootstocks performed the rate of build-up of nematodes (RF) ranging between (0.87 and 6.38) at the inoculum level of (1000 J_2) with Harmony and Richter rootstock respectively. While, the rate of build -up of nematodes (RF) ranging between (1.41 and 9.03) at the inoculum level of (5000 J2) with Harmony and Richter rootstock respectively. The same trend was noticed in season 2022 (Table 6).

Table (4): Contents of N.P.K. percentages in leaves as affected by tested grape rootstocks and some inoculums levels with root-knot nematode in 2021 and 2022 season.

Rootstocks (A)	Inoculums levels (B)	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
		2021	2022	2021	2022	2021	2022
Freedom	Control	2.400	2.300	0.4000	0.4500	1.780	1.810
	1000	2.100	2.267	0.3300	0.4000	1.740	1.760
	2000	1.900	2.183	0.3000	0.1600	1.700	1.720
	3000	1.870	2.150	0.2700	0.1000	1.670	1.690
	4000	1.840	2.117	0.2400	0.2300	1.640	1.670
	5000	1.700	2.000	0.1500	0.1800	1.600	1.610
Mean (A)		1.968	2.169	0.2817	0.3200	1.688	1.710
Harmony	Control	2.600	2.720	0.4100	0.4700	1.830	1.880
	1000	2.580	2.683	0.3800	0.4300	1.800	1.840
	2000	2.500	2.663	0.3600	0.4000	1.780	1.810
	3000	2.400	2.667	0.3300	0.3800	1.750	1.790
	4000	2.350	2.600	0.3200	0.3300	1.740	1.770
	5000	2.300	2.500	0.2800	0.2900	1.700	1.630
Mean (A)		2.455	2.639	0.3467	0.3867	1.767	1.787
Salt Greek	Control	2.500	2.600	0.3300	0.4000	1.550	1.800
	1000	1.900	1.500	0.2600	0.3200	1.483	1.740
	2000	1.500	1.417	0.2000	0.2500	1.430	1690
	3000	1.300	1.300	0.1500	0.1900	1.370	1.650
	4000	1.000	1.200	0.1100	0.1500	1.330	1.620
	5000	0.8000	1.100	0.0800	0.08000	1.100	1.500
Mean (A)		1.500	1.529	0.1883	0.2317	1.377	1.667
Teleki	Control	1.933	2.200	0.3000	0.3700	1.400	1.600
	1000	1.700	1.100	0.2500	0.3200	1.350	1.540
	2000	1.433	1.033	0.2100	0.2700	1.310	1.490
	3000	1.200	0.9500	0.1700	0.2000	1.220	1.450
	4000	0.9000	0.8667	0.1500	0.1700	1.250	1.420
	5000	0.8000	0.7200	0.1000	0.09000	1.000	1.290
Mean (A)		1.328	1.145	0.1967	0.2367	1.263	1.465
SO4	Control	2.000	2.100	0.2700	0.3000	1.200	1.100
	1000	1.100	1.000	0.2000	0.2100	1.130	1.030
	2000	1.030	0.9000	0.1400	0.1600	1.070	0.9700
	3000	0.9500	0.8233	0.09000	0.1200	1.020	0.9200
	4000	0.8667	0.7700	0.05000	0.09000	0.9800	0.8800
	5000	0.7000	0.6900	0.02000	0.07000	0.8300	0.7000
Mean (A)		1.108	1.047	0.1283	0.1583	1.038	0.9333
Richter	Control	1.940	2.000	0.2500	0.2700	1.130	1.000
	1000	1.167	1.000	0.1700	0.1900	1.060	0.9800
	2000	0.8500	0.9000	0.1200	0.1300	1.000	0.8800
	3000	0.7600	0.8100	0.07000	0.03000	0.9500	0.8300
	4000	0.6800	0.7500	0.04000	0.05000	0.9100	0.7900
	5000	0.5000	0.6667	0.02000	0.03000	0.8200	0.6500
Mean (A)		8.9828	1.021	0.1117	0.1250	0.9783	0.8483
Table (B)	Control	2.229	2.320	0.3267	0.3767	1.482	1.532
	1000	1.758	1.592	0.2650	0.3117	1.427	1.475
	2000	1.536	1.516	0.2217	0.2617	1.382	1.427
	3000	1.413	1.450	0.1800	0.2117	1.338	1.388
	4000	1.273	1.394	0.1517	0.1733	1.308	0.358
	5000	1.113	1.279	0.1003	0.1233	1.175	1.230
New L.S.D.	A	0.04305	0.02102	0.009402	0.01051	0.01151	0.01244
at 5%	B	0.04305	0.02102	0.006402	0.01051	0.01151	0.01244
Level	A x B	0.1030	0.05150	0.02303	0.02575	0.02821	0.03047

F.W. = fresh weight
D.W. = Dry weight

Table (5): Effect of different inoculum levels of *Meloidogyne incognita* on six different grape rootstocks on nematode parameters in season 2021.

Rootstocks (A)	Inoculum levels (B)	Galls/root system	Nematode population in					Final nematode population (PF)	Rate of build-up (PF/PI)
			Soil	Root					
				developmental stages	females	Egg-mass	Eggs/ egg-mass		
Freedom	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	8.0	100	15	12	10	167	1797	1.80
	2000	15.0	160	22	20	17	204	3670	1.84
	3000	20.0	200	28	25	24	239	5989	2.00
	4000	25.0	240	35	32	30	269	8377	2.10
	5000	32.0	280	42	39	37	289	11054	2.21
Mean (A)		15.32	163.3	23.67	21.33	18.51	194.7	5148.0	1.6567
Harmony	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	7.0	80.0	10	7	5	155	872	0.87
	2000	11.0	100.0	15	13	11	177	2075	1.04
	3000	17.0	160.0	21	20	18	196	3729	1.24
	4000	21.0	200.0	27	25	23	225	5427	1.36
	5000	25.0	260.0	32	30	27	250	7072	1.41
Mean (A)		12.37	133.3	17.50	15.83	13.42	167.2	3196.0	0.9867
Salt Greek	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	15.0	140	20	17	14	182	2725	2.73
	2000	23.0	220	29	26	24	231	5819	2.91
	3000	27.0	280	33	31	29	295	8899	2.97
	4000	35.0	360	41	37	32	365	12118	3.03
	5000	39.0	480	49	42	39	389	15742	3.15
Mean (A)		21.41	246.7	28.67	25.50	23.33	243.7	7551.0	2.4650
Teleki	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	18.0	180	26	20	17	217	3915	3.92
	2000	25.0	260	34	28	25	310	8072	4.04
	3000	30.0	300	37	35	32	398	13108	4.37
	4000	38.0	380	45	42	40	431	17707	4.43
	5000	45.0	660	56	48	45	482	22454	4.49
Mean (A)		27.20	296.7	33.00	28.83	25.76	306.3	10880.0	3.5417
SO4	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	20.0	300	29	23	20	225	4852	4.85
	2000	32.0	380	39	35	31	334	10808	5.40
	3000	44.0	600	52	49	46	418	19929	6.64
	4000	56.0	940	64	60	58	479	28846	7.21
	5000	67.0	1800	79	75	73	490	37724	7.54
Mean (A)		29.72	670.0	4.383	40.33	29.18	324.3	17030.0	5.2733
Richter	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	31.0	380	36	34	25	237	6375	6.38
	2000	38.0	880	47	41	37	357	14177	7.09
	3000	55.0	1000	65	57	54	439	24828	8.28
	4000	68.0	1240	80	73	70	485	35343	8.84
	5000	88.0	2800	110	88	85	496	45158	9.03
Mean (A)		34.65	1050.0	56.33	48.83	35.27	335.7	20980.0	6.6033
Table (B)	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	11.31	196.7	22.67	18.83	17.50	197.2	3423.0	3.423
	2000	19.42	333.3	31.00	27.17	15.17	268.8	7437.0	3.192
	3000	26.27	423. 3	39.33	36.17	25.88	330.8	12750.0	3.564
	4000	31.29	560.0	48.67	44.83	31.72	375.7	17970.0	3.785
	5000	39.41	1047.0	61.33	53.67	40.31	399. 3	23200.0	3.869
New L.S.D	A	0.6233	11.37	1.316	0.7277	0.7728	2.165	19.86	2.3681
At 5%	B	0.6233	11.37	1.316	0.7277	0.7728	2.165	19.86	2.3681
level	AXB	1.438	27.85	3.225	1.782	1.577	5.303	48.66	0.7463

Table (6): Effect of different inoculum levels of *Meloidogyne incognita* on six different grape rootstocks on nematode parameters in season 2022.

Rootstocks (A)	Inoculum levels (B)	Galls/ root system	Nematode population in					Final nematode population (PF)	Rate of build-up (PF/PI)
			Soil	Root					
				developmental stages	females	Egg-mass	Eggs/ egg-mass		
Freedom	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	5.0	60	9	6	3	153	534	0.53
	2000	9.0	100	13	10	7	168	1299	0.65
	3000	13.0	120	16	15	12	184	2359	0.79
	4000	18.0	170	22	20	17	200	3612	0.90
	5000	22.0	210	26	24	22	222	5144	1.02
Mean (A)		10.30	111.7	15.17	12.67	10.50	154.5	2214.0	0.6900
Harmony	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	4.0	40	8	5	3	150	503	0.51
	2000	7.0	80	12	9	7	165	1256	0.63
	3000	11.0	120	15	14	12	182	2333	0.77
	4000	16.0	160	20	19	17	197	3548	0.88
	5000	20.0	200	25	23	21	220	4868	0.97
Mean (A)		9.53	95.00	13.33	11.50	9.333	152.3	1956.0	0.6006
Salt Greek	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	8.0	100	14	10	8	160	1404	1.40
	2000	15.0	180	19	18	16	197	3369	1.68
	3000	23.0	240	27	25	22	225	5242	1.75
	4000	29.0	300	35	31	27	265	7494	1.87
	5000	35.0	420	40	37	35	289	10612	2.12
Mean (A)		18.21	206.7	22.50	20.17	18.00	189.3	4687.0	1.470
Teleki	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	10.0	120	15	12	9	162	1605	1.60
	2000	18.0	200	20	19	17	200	3639	1.82
	3000	25.0	260	29	27	25	230	6066	2.02
	4000	32.0	340	38	35	32	274	9181	2.30
	5000	39.0	580	48	41	38	310	12449	2.49
Mean (A)		21.19	250.0	25.00	22.33	20.17	196.0	5490.0	1.705
SO4	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	17.0	260	24	18	15	195	3227	3.23
	2000	27.0	380	33	30	27	240	6923	3.46
	3000	36.0	560	41	38	35	299	11104	3.70
	4000	40.0	880	47	44	41	366	15977	3.99
	5000	46.0	1200	55	51	48	435	22186	4.44
Mean (A)		25.31	546.7	33.33	30.17	27.67	255.8	9903.0	3.127
Richter	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	20.0	300	27	21	18	200	3948	3.94
	2000	33.0	440	37	35	30	260	8312	4.16
	3000	37.0	760	45	41	37	340	13426	4.47
	4000	45.0	940	51	49	46	420	20360	5.09
	5000	54.0	1680	62	57	54	464	26855	5.37
Mean (A)		30.75	686.7	37.00	33.83	30.83	280.7	12150.0	3.838
Table (B)	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1000	9.74	146.7	16.33	12.00	9.500	170.0	1896.0	1.896
	2000	17.57	226.7	22.33	20.00	17.33	205.0	4130.0	2.078
	3000	24.15	341.7	28.83	26.67	23.67	243.3	6723.0	2.240
	4000	29.22	465.0	35.67	33.17	29.67	287.0	9963.0	2.486
	5000	37.11	716.7	43.17	38.83	36.33	323.3	13690.0	2.737
New L.S.D	A	0.5541	12.02	1.420	0.6757	0.5538	2.828	4.854	2.02973
At 5%	B	0.5541	12.02	1.420	0.6757	0.5538	2.828	4.854	2.02973
level	AXB	1.369	29.44	3.479	1.655	1.357	6.927	11.89	0.07283

It was showed that the highest nematode population of *M. incognita* in soil and roots was recorded with both SO4 and Richter rootstocks. On the other hand, Salt Greek and Teleki rootstocks recorded moderately population level while, both Harmony and Freedom rootstocks recorded the lowest final nematode population of *M. incognita.* Data also showed that the rate of nematode build – up ranged between (1.41 and 0.97) in Harmony rootstocks at (5000 J_2) in first and second seasons respectively, while, in Richter rootstock were (9.03 and 5.37) at (5000 J_2) in first (2021) and second (2022) seasons, respectively.

Also, data showed variation in the number of galls of *M. incognita* in six different grape rootstocks (Harmony, Freedom, Salt Greek, Teleki, SO4 and Richter). Richter rootstock was the most susceptible one in number of galls than the other rootstocks and recorded the highest number of galls/ root at (5000 J2) (88 galls/ root), while, Harmony rootstock had the lowest number of root galls at the lowest level (5000 J2) were (25 galls/root) in the first season 2021. The same trend was recorded in the second seasons 2022.

The data also revealed that there was a difference between the rate of build-up of nematodes in the two seasons; at the level of inoculum (1000 J2). Whereas the rate of build-up ranged between (0.87 to 6.38) of the season 2021, it was ranged between (0.51 to 3.94) at the season 2022 with Harmony and Richter rootstock respectively. The data also revealed that the rate of build-up at (5000 J2) ranged between (1.41 to 9.03) at the season 2021; it was ranged between (0.97 to 5.37) at the season 2022.

These results might by due to a physical (structural) and / or chemical nature of Harmony than the other rootstocks. These results are agree with Pieterse and Meyer (1987); Anwar and Mckenry (2000 & 2001); Kesba (1999 & 2003); Mckenry, *et al.*, (2001 & 2004); Gehan (2004) and Ola (2007).

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تقييم بعض أصول العنب لمقاومة نيماتودا تعقد الجذور وتأثير ذلك على الصفات الخضرية والكيمائية وكثافة وتوزيع الجذور

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الملخص العربى

أجرى هذا البحث لمدة موسمين2021 و2022 على أصول عنب عمر سنة هذه الأصول هى:Harmony و Freedomو Salt Greek و Teleki و SO4 و Richter وذلك بهدف تقييم هذه الأصول للمقاومة باستخدام مستويات عدوى مختلفة هى (1000 و 2000 و 3000 و 4000 و5000 طور يرقى ثانى / للأصيص) من نيماتودا تعقد الجذور *Meloidogyne incognita* وتم تقدير القياسات لكلا من(الجذور والتربة) لكل الأصص لكل أصل فى نهاية كل موسم .

أوضحت نتائج التقييم الذى أجرى فى هذا البحث تفوق أصلىHarmony و Freedom بالمقاومة بالمقارنة بباقى الأصول . وقد أتصف هذان الأصلان بما يلى : قوة النمو الخضرى ممثلا فى ارتفاع النبات -العدد الكلى للأوراق – الوزن الخضرى للجزء الهوائى الطازج والجاف والمساحة الورقية الكلية للشتلة ومحتوى الأوراق من الكلوروفيل الكلى كذلك تميزت بكثافة جذرية كبيرة وكذلك أطول وأفضل توزيع للجذور الشعرية – المتوسطة وكذلك السميكة وذلك بالمقارنة بباقى الأصول . بالأضافة إلى إحتواء اعناق أوراق هذان الأصلان على تركيزات مرتفعة من كل عنصر النيتروجين والفسفور والبوتاسيوم.

اظهرت الدراسات البيولوجية أن تعداد النيماتودا فى التربة كاعداد اليرقات (الطور اليرقى الثانى) لكل 250 جرام من التربة المحيطة بالجذور وكذلك على جذور النبات كلا من الاطوار اليرقية الغير كاملة و الأناث وعدد كتل البيض على الجذور والتعداد النهائى للنيماتودا ومعدل التكاثر وكذلك عدد العقد النيماتودية على جذور النبات قد زاد زيادة معنوية بزيادة مستوى العدوى بالنيماتودا من 1000 إلى 5000 يرقة . وقد أعطى كلا الأصلين Harmony و Freedom أقل تعداد للنيماتودا فى التربة وعلى الجذور وكذلك معدل التكاثر وعدد العقد النيماتودية على الجذر وبذلك أظهر هذين الأصلين ذو (مقاومة عالية) بينما يعتبر الأصلين Salt Greek و Teleki ذو (مقاومة متوسطة) بينما الأصلين SO4 و Richter من (الأصول الحساسة) لنيماتودا تعقد الجذور .

عموماً من نتائج التقييم المتحصل عليها فإن الأصول الستة موضع الأختبار يمكن ترتيبها طبقاً لدرجة مقاومتها لنيماتودا تعقد الجذور وتأثيرها على النمو الخضرى وتوزيع الجذور طبقاً لظروف هذا البحث كما يلى :- (Harmony و Freedom) و (Salt Greek و Teleki) واخيراً (SO4 و Richter) وطبقاً لذلك فإنه يمكن استخدام أصلى Harmony و Freedom للتطعيم عليهم لمقاومة نيماتودا تعقد الجذور *Meloidogyne incognita* فى مصر.