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Evaluation The Effect of Intercropping Garlic with Grapevines on Productivity, Phytoremediation, Competitive Indices and Plant Parasitic Nematode Community

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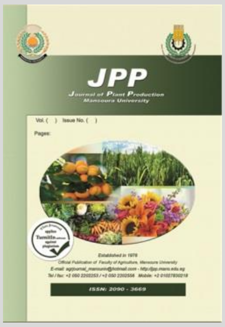

ABSTRACT

The present investigation was carried out during winter of the consecutive seasons (2018/2019 and 2019/2020) on 9 year old Flame Seedless grapevines grown in a private vineyard at Sharkia Governorate, Egypt. Garlic (Balady *cv*) was intercropped with grapevines (Flame Seedless *cv*) on dripper irrigation lines, as a try to reduce numbers of phytonematodes in grapevine soil. For grapevines, the obtained results referred that intercropping insignificantly ($P \leq 0.05$) increased number of berries/bunch, weight of 100 berries and berry firmness, separation force, total soluble solids percentage, anthocyanin content and yield/ vine as well as bunch weight and width, berry length, berry diameter and berry shape index compared to sole grapevines. For garlic (Balady *cv*), the achieved results pointed out that plant height, number of leaves/plant, leaf fresh weight/ plant, nick diameter as well as bulb diameter, height and weight/ plant insignificantly decreased when garlic intercropped with grapevines compared to control. Competition indices; *i.e*., land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) showed that, intercropping garlic with grapevines was more efficient than sole cropping system. Aggressively estimation demonstrated that grapevines were dominant advantages while garlic was dominated. Moreover, intercropping garlic (Balady *cv*) with grapevines was obviously decreased population density of phytonematodes infesting grapevine orchard. Generally, garlic together with other biocontrol agents in grapevine orchards has the potential to be an efficient and environmentally agricultural management method to reduce numbers of plant parasitic nematodes.

Keywords: Grapevines, garlic, intercropping, yield, growth, competitive indices, plant parasitic nematodes.

INTRODUCTION

Grape (*Vitis vinifera*, L.) is one of the most popular and serious fruit crops all over the world, especially in temperate, subtropical and tropical regions with high export possibility. In Egypt, grapes are one of the most widely grown fruit crops. Egypt's grape cultivation is spread geographically from the north to the south and the area dedicated to vineyards is raising year after year. The harvestable area in Egypt reached 77,895 hectares which produced 1,703,394 tons (FAO, 2017). Grapes quality is marked for the consumer, producer as well as exporter. Serious parameters that participate in the quality of grapes include their taste, color, size and texture. Grapes quality is more effective than yield in the excellent table grapes production (Peppi *et al*., 2006).

Garlic (*Allium sativum*, L.) is a substantial crop in Egypt utilized medicinally for processing of microbial infection, hypertension and memory loss (AbouZid and Mohamed, 2011). It is one of the most serious bulb vegetable plants and is next to onion in importance (Hamma *et al*., 2013). Productivity and quality of garlic change greatly with location, cultivar, agricultural methods, soil type and date of harvest.

One of the techniques of land utilization for supreme production is intercropping practice (Bhatnagar *et al*., 2007) which can supply a fundamental yield advantage compared to sole cropping. Suitable intercropping systems could raise the microbial diversity in the growth media (Hauggaard-Nielsen and Jensen, 2005), use several resources more effectively (Javanmard *et al*., 2009) and maximize growth and productivity of crops (Cecilio *et al*., 2011). In addition, Kumari *et al*. (2018) reported that the net income of mango trees was the highest in onion intercrop followed by garlic. Furthermore, the maximum benefit- cost ratio was achieved by onion intercrop.

Phytonematodes are of great economically important pests particularly, root-knot nematodes (RKNs), (*Meloidogyne* spp.), the citrus nematode (*Tylenchulus semipenetrans*) and lesion nematodes (*Pratylenchus* spp.) which are ranked at the top among the five major plant pathogens and the first among the ten most important genera of plant parasitic nematodes in the world (Mukhtar *et al*., 2018 and Ravichandra, 2018). However, the overall average annual yield loss in important horticultural crops worldwide accounts to 13.54 % (Reddy, 2008).

Nowadays, control methods varied greatly by using cultural practice, botanicals, intercropping, resistant cultivars and chemical nematicides. Particularly with RKNs, which is targeted by 48% of global use across crops (Coyne *et al*., 2009). IPM programs are generally

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recommended for the control. As a result of fast acting and considerable results of nematicides, they have been applied widely to control phytonematodes but, they are unfriendly methods, costly and produce environmental hazards. Therefore, research on alternatives to chemical nematicides has received a strong impulse and considered a wide range of options including intercropping and botanical nematicides. Since, a wide variety of plant species, representing 57 families have been shown to have nematicidal compounds such as alkaloids, isothiocyanates, phenols, glycosides, thiophenics, tannins, saponins and fatty acids (Gommers,1981; Akhtar, 2000; Chitwood, 2002; Ntalli and Caboni, 2012).

Various non-chemical alternatives are available for the control of plant parasitic nematodes. However, some non-chemical methods may not be particularly effective when used alone, making integration of methods is necessary to achieve optimal nematode control, particularly in sustainable agriculture. So, this work aimed to evaluate the influence of garlic (Balady *cv*) intercropped with Flame Seedless grapevines on yield and fruit quality of grape as well as growth and yield of garlic . Furthermore, investigate the influence of intercropping garlic on suppressing phytonematodes infecting Flame Seedless grapevines under field conditions.

MATERLIAS AND METHODS

The present investigation was carried out during the two consecutive winter seasons (2018/2019 and 2019/2020) on 9 years old Flame Seedless grapevines grown in a private vineyard at Sharkia Governorate, Egypt. Intercropping system (grape: garlic) was used to evaluated yield and fruit quality of grape (Flame Seedless *cv*) and growth and yield of garlic (Balady *cv*) as well as controlling phytonematodes some competitive indices of grape and garlic. These treatments were arranged in a randomized complete block design with five replicates as a simple experiment.

The grapevines of the experiment were chosen to be nearly similar in growth vigor, healthy as well as uniformly received the ordinary cultural treatments (irrigation, fertilization and pest management). The selected vines were trellised on Spanish Baron System and planted at 2 × 3 m apart in sandy soil conditions under drip irrigation system. Vines were trained on the report of the cane pruning system and pruned to leave around 50 buds/ vine (10 fruit canes/ vine × 5 buds/ cane) at winter of each season. After the fruit set, all experimental vines were adjusted to 30 cluster/ vine and all clusters were tipped to approximately 16 cm length. Some physical and chemical analysis of the experimental soil at 0-30 cm as shown in Table 1, according to Chapman and Pratt (1978).

Table 1. Physical and chemical properties of the used soil (average two seasons)

Physical properties										**Soil texture**	
Clay (%)		Silt (%)		Fine sand (%)			Coarse sand (%)			Loamy sand	
9.3		13.8		18.9			58.0				
Chemical properties											
pH	E.C.	Organic	Soluble cations (meq./L)			Soluble anions (meq./L)			Available (ppm)		
	m.mohs/cm	matter (%)	Mg^{++}	Ca^{++}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
8.03	0.35	0.68	2.63	2.90	1.54	3.45	2.20	1.42	78	16	114

The experimental unit area was (6 m^2) which contained 2 dripper lines (50 cm distance between drippers) with 2 m length and 3 m between rows. One dripper line was utilized for the samples to measure vegetative growth and the other one dripper line was utilized for yield determination. Sole garlic component planted at four dripper lines each of 2 m length and 1m width with the same planting space (50 cm). Each dripper (sole or intercropping system) was planted with 5 cloves. The cultural practices; *i.e.*, irrigation, fertilization, and pest control including weeds were applied in suitable time as recommended for grape and garlic**.**

Data recorded:

For grapevines:

When the total soluble solids (TSS) reached around 16° Brix, grape vines were harvested. Then, each vine bunches (replicate) were picked and the yield/ vine (kg) was listed. Furthermore, five bunches per replicate were randomly chosen to determine the following traits: Bunch weight (g), number of berries/ bunch and 100 berry weight (g). Berry firmness was measured by using a fruit Push-Pull Effegi penetrometer device (Model FD 101) supplemented with a plunger penetrator. Berry removal force was measured by using a hook instead of the plunger. Berry firmness and berry removal force were expressed in Newtons (N). Berry polar length and diameter (cm) utilizing Vernier caliper and then berry shape index; *i.e.*, length/diameter was then calculated.

Also, the chemical constituents of berry were defined in berry juice next being extracted from hundred berries from each replicate. Also, total soluble solids percentage (Brix°) determined by utilizing a hand refractometer. Moreover, total acidity percentage was estimated in the presence of phenolphythalyne by titration against sodium hydroxide (0.1 N) as an indicator. Then, total juice acidity was presented as g tartaric acid per hundred juice ml. Subsequently, each juice sample TSS/ acid ratio was calculated (AOAC, 2012). Samples of berries were lyophilized until a constant weight was obtained. The anthocyanin content was cholorimetrically determined (OD 535 nm) according to the method described by (Francis, 2000).

For garlic:

At 135 days after the planting: Plant height (cm), leaf number per plant, leaf fresh weight per plant (g) and root dry weight per plant (g) were recorded. Also, nick diameter (cm), bulb diameter (cm), height (cm) and weight (g) were tabulated in both seasons. Garlic bulbs were harvested at 200 days after planting. Moreover, at 180 days after planting, ten plants were randomly chosen from each plot to measured number of cloves per bulb and bulb yield (ton/ fed). Also, total soluble solids percentage (TSS) in garlic bulbs was determined according to A.O.A.C (2012).

Competitive indices:

Land equivalent ratio (LER):

This parameter was determined for grapevines and garlic yield recorded per feddan as specified by Mead and Willey (1980) equation as follows:

$$LER = Lv + Lg,$$

$$Lgrapevine\ s\ (Lv) = \frac{Yvg}{Yvv}$$

$$Lgarlic(Lg) = \frac{Ygv}{Ygg}$$

Where: **Lv and Lg are the relative yield of grapevines and garlic, respectively, as well as Yvv and Ygg are the yields per feddan of grapevines and garlic, respectively, as sole crops and Yvg and Ygv are the yields of grapevines and garlic, respectively, as intercrop yields of each components.**

Area time equivalent ratio (ATER):

ATER was calculated as specified by Hiebsch and McCollum (1987) equation as follows:

$$ATER = \frac{Yvg/Yvv \times tv + Ygv/Ygg \times tg}{T}$$

Where: **Yvg = intercropped yield of grapevines, Yvv = sole yield of grapevines, Ygv = intercropped yield of garlic, Ygg = sole yield of garlic, tv = the duration of grapevines in days (365 days), tg = the duration of garlic in days (200 days) as well as T= the overall duration by days of intercropping system.**

Land utilization efficiency percentage (LUE%)

By utilizing ATER and LER values between grapevines and garlic, the land utilization efficiency percentage (LUE %) was studied as specified by Mason *et al.* (1986) equation as follows:

$$LUE = \frac{LER \times ATER}{2} \times 100$$

Aggrissivity (A):

Mc Gilchrist (1965) equation was utilized to calculated aggressively value as follows: they were calculated according to the following equations, for combination of 50:50 and 100:100,:

$$Avg = Lv - Lg \quad \text{and} \quad Agv = Lg - Lv$$

Effect of intercropping garlic on the population density of phytonematodes infesting soil of grapevine orchard:

Nematode samples were collected from Flame Seedless grapevines during two consecutive seasons. According to the experimental design mentioned before, the selected grapevines were separated from each other by one parallel row and labeled. The control treatment was left without intercropping garlic plants. Five subsamples were taken at depth of 15-27cm from the rhizosphere area and near the trunk of each vine with a hand trowel after two, four and six months of intercropping garlic areas or control treatments. Subsamples were mixed together to form a composite sample of about 1 kg, reserved in polyethylene bags. Icebox was used to keep samples at 18°C, immediately sent to the laboratory for nematode extraction.

Nematode extraction was processed by using an aliquot sample of 250 g. Extraction was done by using a combination of sieving and Baermann trays technique (**Hooper *et al*., 2005**). For nematode identification, one ml of nematode suspension was pipetted into Hawksely counting slide and nematodes were examined with the aid of the research microscope under 100X magnification. Based on morphology of adult and juvenile forms nematodes were identified according to Mai and Lyon (1975) and Siddiqi (1986). Species of *Meloidogyne* were identified on the basis of perineal pattern according to Eisenback *et al.* (1981). The nematode reduction (%) was calculated according to the following equation:

$$Reduction\ (\%) = \frac{Control - Treated}{Control} \times 100$$

Experimental design and statistical analysis:

This experiment included 3 treatments (sole grapevines, sole garlic and intercropping system treatment). The statistical layout of this experiment was completely randomized block design. The least significance difference (LSD) was utilized to differentiate means at the at 5 % level of probability. The obtained means were compared utilizing Statistic version 9 computer program (Analytical software, 2008).

RESULTS AND DISCUSSION

Grapevines yield and its quality:

Data presented in Table 2, reveal that intercropping garlic under grapevines insignificantly increased yield per vine, bunch weight and bunch width compared to sole grape during both seasons. In contrast, bunch shape index was insignificantly decreased under intercropping system compared to sole planting. Number of berries per bunch, weight of 100 berries, separation force and berry firmness increased by using garlic as intercropping system under grapevines without significant difference compared to sole grape (Table 3). Moreover, berry length, berry diameter and shape index of grape were increased with intercropping treatment by garlic compared to sole planting (Table 4). Furthermore, garlic as intercropping system insignificantly increased total soluble solids (TSS), acidity and TSS/acid ratio as well as anthocyanin content of grape berries compared to sole grapevines planting (Table 5).

Table 2. Effect of intercropping garlic entire grapevine rows on yield/vine (kg), bunch weight (g), bunch width (cm) and bunch shape index during 2018/2019 and 2019/2020 seasons

Treatments	Yield/vine (kg)		Bunch weight (g)		Bunch width (cm)		Bunch shape index	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole grapevine	12.7	13.3	418.9	439.5	14.2	15.0	1.13	1.07
Intercropping system	13.8	14.6	455.7	483.1	14.7	15.4	1.09	1.04
LSD at 5%	2.88	1.92	71.99	68.03	5.81	5.84	0.44	0.30

Table 3. Effect of intercropping garlic entire grapevines rows on number of berries/bunch, weight of 100 berries (g), separation force (N) and berry firmness (N) during 2018/2019 and 2019/2020 seasons

Treatments	Number of berries/bunch		Weight of 100 berries (g)		Separation force (N)		Berry firmness(N)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole grapevines	127.0	131.4	326.4	331.8	7.11	7.33	6.13	6.27
Intercropping system	132.5	140.2	340.6	343.1	7.30	7.52	6.27	6.40
LSD at 5%	17.23	10.33	23.81	9.51	0.65	1.11	0.30	0.86

Table 4. Effect of intercropping garlic entire grapevines rows on berry length (cm), berry diameter (cm), berry shape index, during 2018/2019 and 2019/2020 seasons

Treatments	Berry length (cm)		Berry diameter (cm)		Berry shape index	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole grapevines	1.60	1.72	1.71	1.64	0.94	1.05
Intercropping system	1.66	1.78	1.73	1.69	0.96	1.05
LSD at 5%	0.34	0.53	0.34	0.28	0.69	0.39

Table 5. Effect of intercropping garlic entire grapevines rows on TSS (Brix°), acidity (%), TSS/acid ratio and anthocyanin (mg/kg) content during 2018/2019 and 2019/2020 seasons

Treatments	TSS (%)		Acidity (%)		TSS/acid ratio		Anthocyanin (mg/kg)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole grapevines	18.3	17.0	0.58	0.57	31.5	29.9	418.2	402.4
Intercropping system	18.7	17.6	0.57	0.56	32.8	31.4	424.6	411.0
LSD at 5%	2.40	1.14	0.05	0.07	3.99	4.73	53.02	93.76

The improvement in yield and quality of grapes can be attributed to a reduction in the extent of nematode infestation in the growing media, resulting in improved growth and thus increased yield and its quality. This trend may as a result of garlic allelopathy conferredby compounds. Garlic effectiveness is depending on the released sulfur compounds. These compounds may be assimilated through anaerobe, where spread inorganic sulphide like H_2S which is has a toxicity effect for root knot nematodes (Gong *et al*., 2013).

In the same line, Kanwar *et al*. (1993) demonstrated that intercropped medicinal plants in orchards of citrus and mango enhanced fruit quality as TSS, acidity, total sugar content and fruit weight compared to sole planting system. Also, the growth parameters and yield quality of *Pongamia pinnata* trees were improved when intercropped with sweet basil plants (Suvera *et al*., 2015). Similarly, Nandi and Ghosh (2016) indicated that, one year growing of medicinal plants pointed out that *Pudina* and *Bramhi* can be cultivated in the inter space of the orchard with no adverse influence on *Mosambi* sweet orange. Fruits quality (TSS, total acidity % and anthocyanin content) of pomegranate trees were significantly increased under intercropping with sweet basil or rosemary plants (Ali *et al*., 2019).

Garlic growth and yield components:

As shown in Table 6, plant height, leaf number per plant, fresh weight of leaves per plant and root dry weight per plant of garlic were insignificantly decreased with intercropping system treatment compared to sole crop, in most cases, during the two consecutive seasons. The decreases in plant height were about 15.17 and 22.51 % for the intercropping system over control treatment (sole garlic planting) in the 1st and 2nd seasons, respectively. In other words, garlic yield components, in most cases were significantly decreased when intercropped under grapevines compared to the sole planting system in both seasons (Table 7). The decreases in bulb weight per plant were 31.24 and 28.91 % for the intercropping system over control treatment (sole garlic planting) in the 1st and 2nd seasons, respectively. Furthermore, cloves number per bulb significantly increased when garlic intercropped with grapevines compared to sole garlic in both seasons (Table 8), While, total bulb yield per feddan significantly decreased under intercropping system compared to sole crop. There is no significant difference regard TSS percentage in the first season but it significant decrease when garlic intercropped with grapevines compared to sole planting in the second one. These results are following with those found by Jiang *et al*. (1994) on lettuce, garlic, wheat-maize and sweet potato-wheat-tobacco when intercropped with *Paulownia* trees as well as Sujatha *et al*. (2011) on *Ocimum basilicum* and *Artemisia pallens* when intercropped with arecanut (*Areca catechu*, L.) trees.

Table 6. Effect of intercropping garlic entire grapevine rows on plant height (cm), number of leaves per plant, the weight of leaves per plant (g) and root dry weight per plant (g) of garlic at 135 days after planting during 2018/2019 and 2019/2020 seasons

Treatments	Plant height (cm)		Number of leaves per plant		Fresh weight of leaves per plant (g)		Root dry weight per plant (g)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1s Season	2nd Season
Sole garlic	83.7	82.2	9.33	9.7	55.8	51.8	2.97	3.57
Intercropping system	71.0	63.7	8.33	9.0	36.2	25.5	2.77	2.80
LSD at 5%	31.92	34.62	2.48	5.17	36.05	16.77	0.66	0.83

Table 7. Effect of intercropping garlic entire grapevine rows on nick diameter (cm), bulb diameter (cm), bulb height (cm) and bulb weight per plant (g) of garlic at 135 days after planting during 2018/2019 and 2019/2020 seasons

Treatments	Nick diameter (cm)		Bulb diameter (cm)		Bulb height (cm)		Bulb weight per plant (g)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole garlic	1.70	1.60	3.90	3.97	4.23	4.03	32.97	33.90
Intercropping system	1.40	1.10	3.00	3.13	3.37	3.27	22.67	24.10
LSD at 5%	0.25	0.43	1.55	1.15	0.76	0.14	8.98	11.71

Table 8. Effect of intercropping garlic entire grapevines rows on cloves number per bulb, yield per feddan (ton) and total soluble solids percentage of garlic plant during 2019 and 2020 seasons

Treatments	Cloves number / bulb		Yield /feddan (ton)		Total soluble solids (%)	
	2019	2020	2019	2020	2019	2020
Sole garlic	15.30	15.57	1846.1	1898.4	34.77	35.30
Intercropping system	16.90	18.10	634.67	674.80	34.80	34.60
L.S.D. at 5%	0.86	0.52	483.42	511.32	0.87	0.25

Competitive indices between grapevines and garlic plants:

Results in Table 9, reveal that the competitive indices as combined yield utility in terms of LER, ATER and LUE % were the greatest when garlic intercropped with grapevines (1.27, 1.27 ; 1.12, 1.11 and 119.28 , 119.13) during 1st and 2nd seasons, respectively, compared to sole crop. Indeed, intercropping of garlic and grapevines was extra productive than growing them single (sole crop), as can be visible from the below pointed values which were better than 1.00. The obtained results were true in both seasons. This could be due to the reason that grapevines/garlic intercropping system planted in the same intra and inter row spacing accord suitable more efficacious total resource utilization and greater overall production than sole planting and the staying intercropping arrangements. Furthermore, aggressively (A) values of grapevines (Avg) and garlic plants (Agv) were calculated for fruits and bulb yield per feddan of grapevines as well as garlic, respectively. In particular, grapevines were the dominated one (Avg positive), while, garlic was the dominant species (Agv negative). The same results were recorded by (Ali *et al*., 2019) when rosemary or sweet basil was intercropped with pomegranate trees.

Table 9. Effect of intercropping garlic entire grapevines rows on competitive indices between grapevines and garlic components during 2018/2019 and 2019/2020 seasons

Treatments	Land equivalent ratio (LER)		Area time equivalent ratio (ATER)		Land utilization efficiency (LUE %)		Aggressively of grapevines to garlic (Avg)		Aggressively of garlic to grapevines (Agv)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Sole garlic	1.00	1.00	1.00	1.00	100.00	100.00	+0.00	+0.00	-0.00	-0.00
Intercropping system	1.27	1.27	1.12	1.11	119.28	119.13	+0.58	+0.56	-0.58	-0.56
LSD at 5%	0.11	0.17	0.15	0.13	12.98	14.83	0.29	0.22	0.29	0.22

Influence of intercropping garlic on phytonematodes infesting soil of grapevine orchard:

Intercropping garlic (*Allium sativum* L.) significantly (P ≤ 0. 05) decreased numbers of phytonematodes (Table 10). The inhibitory effect varied according to garlic sample and nematode species. The highest values were detected with 1E and 3F site samples with percent reduction reached 97.0, 93.4; 76.66, 74.89; 89.26, 93.71; 93.64, 92.24 and 92.36, 91.78 %, with *M. incognita*, *R.**reniformis.***, *Pratylenchus* spp., *Helicotylenchus* spp. and *Tylenchorhyncus* spp., respectively. While, the lowest values were observed with 2F with percent reduction of 72.19, 63.83, 93.0, 89.72 and 89.43 % with *M. incognita, R.reniformis, Pratylenchus* spp., *Helicotylenchus* spp. and *Tylenchorhyncus* spp., respectively.

Table 10. Effect of garlic intercropping on numbers of *Meloidogyne incognita*, *R.reniformis*, *Pratylenchus* spp., *Helicotylenchus* spp. and *Tylenchorhyncus* spp. under field condition in 2018/2019 season

Site/Treatments		*M. incognita*	*R. reniformis*	*Pratylenchus* spp.	*Helicotylenchus* spp.	*Tylenchorhyncus* spp.
	Control	23.10a	175.70a	17.70a	40.90a	39.30a
1E	Intercropping	0.60b	41.00b	1.90b	2.60b	3.00b
	Reduction %	(97.40)	(76.66)	(89.26)	(93.64)	(92.36)
	Control	26.00a	201.80a	10.50a	33.20a	48.80a
2E	Intercropping	2.50b	49.50b	1.60b	3.50b	4.30b
	Reduction %	(90.38)	(75.47)	(84.76)	(89.45)	(91.18)
	Control	22.30a	160.10a	18.70a	25.30a	30.30a
2F	Intercropping	6.20b	57.90b	1.30b	2.60b	3.20b
	Reduction %	(72.19)	(63.83)	(93.04)	(89.72)	(89.43)
	Control	24.40a	192.40a	17.50a	24.50a	43.80a
3F	Intercropping	1.60b	48.30b	1.10b	1.90b	3.60b
	Reduction%	(93.44)	(74.89)	(93.71)	(92.24)	(91.78)

*** Values represent number of nematodes per 250 g soil.**
*** Each value is a mean of 5 replicates.**
*** Values in brackets indicate % reduction**

$$\cdot \text{ Reduction } (\%) = \frac{\text{Control - Treated}}{\text{Control}} \times 100$$

The parallel values in the second season (Table 11) were 63.09, 39.24, 87.50, 88.90 and 88.14% with *M.incognita*, *R.reniformis*, *Pratylenchus* spp., *Helicotylenchus* spp. and *Tylenchorhyncus* spp., respectively. Generally as shown in Tables (10 and 11), intercropping garlic caused marked decrease in population density of tested plant parasitic nematodes. Intercropping was more effective in the first season compared to that in the second one.

Due to restrictions governing the use of nematicides and chemical soil fumigants in place, environmentally friendly or sustainable control options are in demand on conventional as well as organic farms. Among eco-friendly methods used to control plant parasitic nematodes (PPNs), a practical strategy such as intercropping was used in organic farms especially in intensively-cultivated greenhouse and field production (Liu *et al*., 2006). Sulphur compounds which found in liliaceous crops, such as *Allium sativum* L., *Allium cepa* L. and *Allium fistulosum* L., are hydrolyzed to form a variety of isochiocyanates with broad nematicidal, fungicidal, antibiotic and phytotoxic effects (Choi *et al*., 2007).Moreover, the release of sulfur-containing compounds from garlic playing an important role in controlling phytonematodes (Biao Gong *et al*.,2013).

Table 11. Intercropping effect of garlic (*Allium sativum* L.) on numbers of IJs of *Meloidogyne incognita*, *Rotylenchulus* spp., *Pratylenchus* spp., *Helicotylenchus* spp. and *Tylenchorhyncus* spp. under field condition in 2019/2020 season

Site/Treatments		*M. incognita*	*R. reniformis*	*Pratylenchus* spp.	*Helicotylenchus* spp.	*Tylenchorhyncus* spp.
	Control	17.60a	109.90a	7.50a	34.10a	37.50a
1E	Intercropping	0.60 b	41.00b	1.60b	2.60b	3.00b
	Reduction %	(96.59)	(62.69)	(78.66)	(92.37)	(92.00)
	Control	18.70a	128.80 a	8.80a	25.70a	43.30a
2E	Intercropping	2.50b	49.50b	1.90 b	3.50b	4.30b
	Reduction %	(86.63)	(61.56)	(78.40)	(86.38)	(90.06)
	Control	16.80a	95.30a	10.40a	23.60a	27.00a
2F	Intercropping	6.20b	57.90b	1.30b	2.60b	3.20b
	Reduction %	(63.09)	(39.24)	(87.50)	(88.98)	(88.14)
	Control	15.80a	101.60 a	9.80a	18.90a	35.80a
3F	Intercropping	1.60b	48.30b	1.10b	1.90b	3.60b
	Reduction%	(89.87)	(52.6)	(88.77)	(89.94)	(89.94)

*** Values represent number of nematodes per 250 g soil.**
*** Each value is a mean of 5 replicates.**
*** Values in brackets indicate % reduction**

$$\cdot\ \text{Reduction}\quad (\%) = \frac{\text{Control - Treated}}{\text{Control}} \times 100$$

Many literatures have been assembled expressing that Garlic's residues can produce the damage to vegetable crops by nematode and other soil-borne diseases (Park *et al*., 2005; Choi *et al*., 2007; Danquah *et al*., 2011).

Intercropping significantly increased root dry weight, and much less substantially shoot dry weight and plant height (Zhang *et al*., 2015). Chinese leek possesses a high resistance to root knot nematodes, has strong nematicidal activity against *M. incognita* and can significantly reduce the incidence of disease caused by nematodes (Huang *et al.,* 2016).

Youssef and El-Nagdi, 2012 showed that nematode criteria decreased in sugar beet roots intercropped with garlic, either three or six months after inoculation and the reduction due to garlic cloves contain pyruvic acid and ammonia together with diallyl disulphide. Moreover, Nigh,1985 revealed that garlic possess biochemical substances of which allelopathic substances are toxic to nematodes or garlic contents of allelopathic substances or that garlic did not provide essential elements for nematode development. The population of *R. reniformis* and *M. incognita* were significantly reduced in garlic monoculture or when garlic was intercropped with vegetables such as tomato (Ameen ,1996).

The combination between different control methods (cultural, chemical, resistant cultivars, intercropping and naturally occurring biological control agents) could be playing a significant role in the management of phytonematodes (Abd-Elgawad, 2019).

Generally, obtained results clear that the intercropping system can be a way to produce more income and reducing the cost of the utilized resources with efficent way.

CONCLUSION

The present study showed that intercropping of garlic (Balady *cv*) with grapevines (Flame Seedless *cv*) affects growth and productivity of the two species and also the competitive indices between them. This system of inetrcropping is promissing in line of sustainble production. Also, intercropping garlic with grapevines was effective in reducing damage caused by the root-knot nematode, *M.incognita* which considered the most destructive PPNs, and increased yield of grapevine. All these benifets were achived without adding or modify the used irrigation and fertilization programme of grapevines. They could be used by the producers under the same conditions as it is a profitable systems of cultivation with high yield advantages. Garlic plants were effective in reducing number of nematode and increased grape production as a result of the release of sulfur compounds likely, which playing a main role.

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تقييم تأثير تحميل الثوم مع العنب على الإنتاجية والمعالجة النباتية والعلاقات التنافسية ومجتمع النيماتودا المتطفلة على النبات

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أجري هذا البحث خلال شتاء الموسمين المتتاليين (2019/2018 و 2020/2019) على كرمات العنب "صنف فليم سيدلس" عمرها 9 سنوات مزروعة في مزرعة عنب خاصة بمنطقة أبو حماد بمحافظة الشرقية، مصر، تمت زراعة الثوم (صنف البلدي) مع العنب (صنف فليم سيدلس) على خطوط الري بالتنقيط ، كما تم زراعتها كمحصول منفرد للمقارنة، كان الهدف من هذه التجارب هو تقييم مكونات محصول العنب وجودته بالإضافة إلى نمو وإنتاجية نباتات الثوم والعلاقات التنافسية بينهما، بالإضافة إلى محاولة تقليل أعداد النيماتودا التى تصيب العنب. بالنسبة للعنب، أشارت النتائج المتحصل عليها إلى أن زراعة الثوم (صنف البلدي) مع العنب أدت إلى زيادة عدد الحبات لكل عنقود ووزن مائة حبة وقوة شد الحبة مع عدم وجود فرق معنوي بين الزراعة تحميلاً وزراعة العنب منفرداً، كما لوحظ نفس الاتجاه فيما يتعلق بالنسبة للمواد الصلبة الذائبة الكلية والمحتوى من الأنثوسيانين والمحصول لكل كرمة، وكذلك وزن وعرض العنقود وطول الحبة وقطر الحبة ومؤشر شكل الحبة. أما بالنسبة للثوم، أشارت النتائج المتحصل عليها إلى أن ارتفاع النبات، وعدد الأوراق لكل نبات، والوزن الطازج للأوراق لكل نبات، وقطر العنق، وقطر البصلة، وارتفاع البصيلة ووزن البصلة لكل نبات، انخفض بفارق غير معنوي عند تحميل الثوم مع العنب عند المقارنة بالكنترول، وأظهرت العلاقات التنافسية مثل نسبة المكافئ الأرضي، ونسبة المكافئ الأرضي لوحدة الزمن، وكفاءة استخدام الأرض، وقد خلصت الدراسة الى أن تحميل الثوم (صنف البلدي) مع كروم العنب كانت أكثر فائدة من نظام الزراعة المنفردة لكروم العنب، كما أظهر تقدير العدوانية أن العنب كان سائداً، بينما كان الثوم هو المسود عليه، علاوة على ذلك أدت زراعة الثوم محملاً مع العنب إلى انخفاض واضح في أعداد النيماتودا، ويعد استخدام الثوم مع عوامل المكافحة الحيوية الأخرى فى بساتين العنب من وسائل المكافحة الصديقة للبيئة وتظهر فعالية كبيرة فى خفض أعداد النيماتودا المتطفلة على النبات.