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Effect of The Edaphic Environment on The Diversity And Trophical Structure of The Nematodes of Algerian Viticultural Soils

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ABSTRACT

In the ecosystem, the environment conditions, the host plant and the biotic relationships are very important in order to determine the variations observed in the nematological stands. In the present work, we studied the composition of soil in 10 nematofauna wine stations to determine the end of generic and trophic diversity of terrestrial pests and explain the influence of some physicochemical soil factors on these nematode fluctuations. The inventory of the nematological stand associated with the vine was carried out in ten vineyards in western of Algeria during the wine of year 2013/2014. The soil samples are taken from the various vineyards surveyed at a depth of 40 to 70 cm, ie 10 samples of 200 to 300 g are harvested at random in the rhizosphere of the vines. The nematological analysis nematodes associated with viticulture revealed the present of sixteen kinds of nematode divided according to their diets 4 trophic groups whose phytophagous are the most abundant (*Paratylenchus* sp., *Pratylenchus* spp., *Tylenchus* sp., *Tylenchorhynchus* sp., *Helichotylenchus* sp., *Scutellonema* spp., and *Xiphinema* sp.), followed by fungivorous (*Aphelenchus* sp., *Aphelenchoides* spp., *Ditylenchus* spp. and *Psilenchus* sp.) and the bactériovores (*Cephalobus* sp., *Chiloplacus* sp. and *Rhabditis* sp .), While the lowest densities are recorded for the omnivorous predators (*Mononchus* sp. and *Dorylaimus* sp.). In addition, the highest densities of nematodes are reported in the soils of stations L2 and L5 with an abundance of both genera *Cephalobus* and *Dorylaimus*. This study also illustrates the effect of soil physicochemical fluctuations on the activity and abundance of nematodes whose nematodes are sensitive to high levels of silt and clay; while the latter support life in sandy soils. Also, both groups of bacteriovorous and fungivorous abound in soil rich in organic matter but the group of fungivores is sensitive to *Phosphorus*.

KEYWORDS: trophic groups; Physico-chemical fluctuations; West Algeria; Nematological population; vine.

INTRODUCTION

Nematodes are certainly the most abundant and widespread multicellular organisms. They are found in oceans, coastal sands, seas, lakes, rivers and soils. They were thawed alive from polar ice and harvested from hot springs above 50° C. They have even adapted to an environment as special as wine vinegar. All Nematodes, however, remain aquatic or highly hygrophilic animals, and when there is no film of water; they die, pass slowly, become dehydrated, or encysted [3].

Nematodes are an important position in the food chain detritus [14, 21], by significantly affecting the decomposition of soil organic matter and nutrient mineralization plants [19]. These organisms can be used as indicators sensitive to changes in ecosystems [4]. Analyses of nematode communities combined the functions of ecosystems are of interest in assessing soil ecology [31, 32]. Both in natural areas and agricultural communities' nematodes are used to estimate the effects of pollution [30], and also as indicators of enrichment and imbalance [4, 13].

In agriculture soil, the influence of soil's environment on nematode's dynamics is considered to be the second most important factor after the host plant [24, 9]. The physical and chemical properties of soil such as grain size, mineral salts, pH and organic matter influence the distribution and abundance of different species. Some species don't survive prolonged flooding while others are flooded with rice paddies. Some genera proliferate in sandy soils while others prefer clay soils. For this reason, it is useful to survey our vineyards and take soil samples in order to analyze, to identify and to determine the importance of their nematofauna as a result of variations in the physicochemical characteristics of the soil.

MATERIEL AND METHODS

1. Study stations and climate:

The inventory of soil's nematodes associated with viticulture in Algeria was carried out in 10 stations in western Algeria, considered as potential area in viticulture, covering areas of 1 ha - 8 ha planted with a planting distance of 4 m x 2 m. Our study area is characterized by a Mediterranean (continental) climate whose rainfall is mainly in winter and spring, where annual rainfall is on average 650 mm. These stations are shown in the table below:

Regions	Stations	Coordonnés géographiques	Variétés	Porte Greffe	Age
Ain Temouchent	L1 L2	35°22'44"N 00°58'04''W 35°26'16''N 01°03'05''W	Dattier Dattier	41B SO4	15 08
Mostaganem	L3 L4	35°49'50''N 00°00'25''W 35°56'00''N 00°05'00''E	Carignan Carignan	SO4 SO4	10 16
Oran	L5 L6	35°49'06''N 00°15'25''W 35°40'00''N 00°25'00''W	Carignan Carignan	SO4 SO4	28 28
Mascara	L7 L8	35°25'24''N 00°08'09''E 35°24'00''N 00°08'26''E	Cinsault Cinsault	41B 41B	40 40
Relizane	L9	35°54'41''N 00°30'50''E	Mokrani	/	10
Sidi Belabes	L10	35°01'39''N 00°53'00''E	Cinsault	/	30

2. Methdology:

To achieve this faunal study, we collected a mixed sample under a weight of 200g to 300g soil to one sample every 10 m on projection diagonally from each plot (unit cultivation). Soil sampling is carried out in the rhizosphere of the plants at a depth between 40 and 70 cm from the soil. These funds are collected in a single sample of approximately 1 kg in a referenced bag (date, place and variety).

In the laboratory, each soil sample is mixed well and then divided into four: a quantity of 750 $dm^3$of soil (3/4) suffered from the physical soil analyzes: the size, the dosage of limestone (total), soil moisture and chemical analysis: determination of assimilable phosphorus, assimilable potassium, water pH, electrical conductivity and finally the dosage of organic matter. A quantity of 250 dm^3 (1/4) of soil is used for the extraction of nematodes by the method of extraction of the buckets of Dalmasso [10] called flotation and sedimentation methods. After extraction, the nematode's soil is purified by active passage. Then, Nematodes are recovered to count and to identify under a dissecting microscope using identification keys of Mai and Lyon [23], Brzeski [7] and Yeate et al. [33]. Soil nematode populations are expressed as nematode numbers per dm^3 (N / dm3).

3. Statistical analysis:

Data analysis and graphical representations were performed using the SYSTAT software vers. 12, SPSS software 2009, and Excel TM. Means were separated by the global linear model (GLM) at a significance level of $\alpha = 5\%$ .The correlations between physical and chemical components of the soil and trophic groups of soil nematodes in the various stations of study are highlighted by correlation coefficient. In parametric conditions, this is the Pearson coefficient r, and in nonparametric conditions, the spearman coefficient rho through the PAST software - Palaeontological Statistics, ver. 1.81. [20].

Results:

1. Inventory of the nematofauna encountered in study stations:

The completion of this study allowed us to identify sixteen genera of nematode in ten vineyards of western Algeria represented by: *Pratylenchus, Paratylenchus, Scutellonema, Tylenchorhynchus, Xiphinema,*

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Helicotylenchus, Aphelenchoides, Aphelenchus, Ditylenchus, Psilenchus, Tylenchus Rhabditis, Cephalobus, Chiloplacus, Mononchus and Dorylaimus.

The study of the structure of nematode communities (abundance, frequency) in these stations study (table 1) allows us to rank the most abundant genera *Aphelenchus*, *Tylenchus*, *Dorylaimus* and *Cephalobus* with relative abundance which are respectively : 15.194 and 14.723 and 12.603 and 12.485. The most dominant group is that of phytophagous (35.689) followed by fungivorous and bacterivorous (respectively: 21.436 and 21.436)

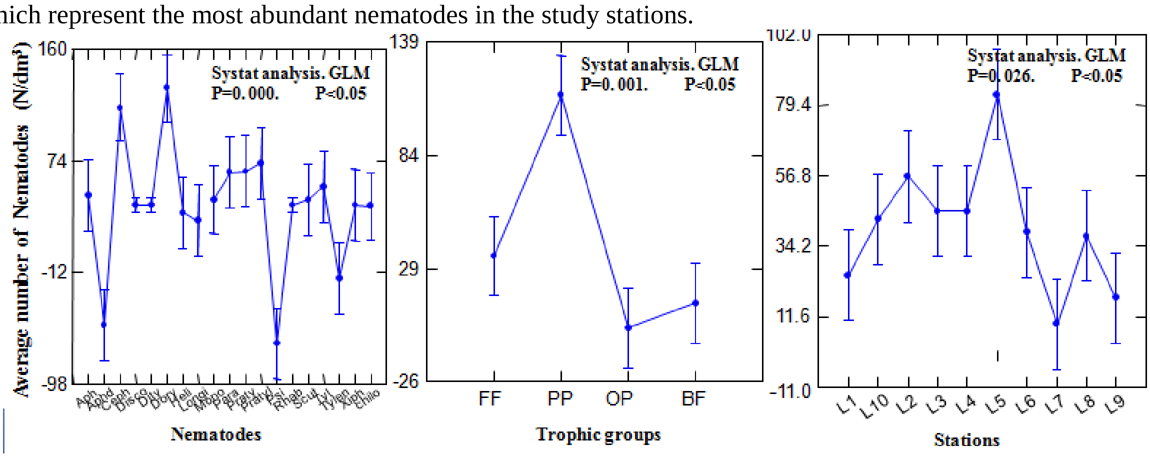
Table 1: Frequency/ Abundance of nematode communities found in West Algerian vineyards.

Genus	*Familly*	*Frequency (%)*	*Absolute Abundance (N/dm³)*	*Relative Abundance (%)*
OP			123	*13.074*
Mononchus	Mononchidae	10	4	0.471
Dorylaimus	Dorylaimidae	90	119	12.603
BF			203	21.436
Rhabditis	Rhabditidae	60	37	3.886
Cephalobus	Cephalobidae	90	118	12.485
Chiloplacus	Cephalobidae	70	48	5.064
FF			280	29.799
Aphelenchus	Aphelenchidae	100	143	15.194
Aphelenchoides	Aphelenchoididae	40	22	2.355
Ditylenchus	Tylenchidae	100	102	10.836
Psilenchus	Tylenchidae	30	13	1.413
PP			364	35.689
Tylenchus	Tylenchidae	100	139	14.723
Tylenchorhynchus	Belonolaimidae	80	51	5.418
Pratylenchus	Pratylenchidae	50	24	2.591
Paratylenchus	Tylenchulidae	70	38	4.004
Helicotylenchus	Hoplolaimidae	30	13	1.413
Scutellonema	Hoplolaimidae	40	17	1.766
Xiphenema	Longidoridae	30	13	1.413
Total			1021	

2. Variation in the average abundance of soil nematodes associated with viticulture:

The G.L.M. Applied to the variability's mean abundances of the nematofauna existed in different stations shows a highly significant difference between the distribution of the nematodes ($p = 0.000$, $p < 0.05$). The differences are significant between trophic groups and nematode's distribution in study stations ($p = 0.001$ and $p = 0.026$; $P < 0.05$).

The results obtained allow us to deduce that the mean abundances of the most important nematodes are reported in L5 sites (Ain Temouchent) and then in L2 sites (Oran). However, these abundances vary depending on the trophic groups with the highest densities recorded for the phytophagous group followed by the fungivorous and bacterivorous groups and the lowest one recorded for omnivorous-predators. Similarly, the density of nematodes also varies according to the genus encountered of which *Cephalobus* and *Dorylaimus* which represent the most abundant nematodes in the study stations.



Graph 1: G.L.M. Model applied to the global average density (N/dm3) of diverse nematodes associated with Vine.

PP : Plant-Parasitic nematodes ; BF : Bacterial feeders; FF : Fungal Feeders; OP : Omnivorous-Predator nematodes, *Aph* : *Aphelenchus, Aphd : Aphelenchoides, Tyl : Tylenchus, Dity : Ditylenchus, Psi : Psilenchus, Ceph : Cephalobus, Chilo : Chiloplacus, Rhab : Rhabditis, Scu : Sculellonema, Tylen : Tylenchorhynchus,* *Helico : Helicotylenchus, Praty : Pratylenchus, Para : Paratylenchus, Xiph : Xiphinema, Dory :Dorylaimus, Mono : Mononchus.*

3. Effect of soil physical and chemical characteristics on nematode trophic groups:

To evaluate the influence of physicochemical characteristics of soil on trophic groups, we chose the correlation analysis which shows the data (table 2 and table 3). In these tables, the Pearson coefficient values are below the diagonal. The associated probabilities are positioned above the diagonal.

The results shown in table 2 reveal that the phytophagous and bacterivorous nematodes are positively correlated with coarse and fine sand. On the contrary, these same groups are negatively correlated with silt and clay soil. The respective probabilities for these correlations are identical for phytophagous (p = 3.70E-05) and for bacterivorous (p = 6.76E-5).

While the results shown in table 3 show a negative correlation between the phosphorus content and the fungivorous group (p = 3.33E-02). Similarly, this table reveals that bacterivorous and fungivorous are positively correlated to the organic matter (p = 0.03 and p = 0.01).

Table 2: Correlations between soil physical characteristics and trophic groups

	CaCo3	RH	CS	FS	C	S	BF	FF	PP	OP
CaCo3	0	0,1606	0,8425	0,5914	0,5332	0,21173	0,20369	0,82448	0,80176	0,0894
RH	0,7309	0	0,654	0,7875	0,9456	0,77759	0,76674	0,88776	0,50722	0,5152
CS	0,124	-0,275	0	6.74 E-186	6.73E-186	6,78E-186	6,76E-05	0,12	3,70E-05	0,454
FS	-0,3268	0,1677	1	0	6.74 E-186	6,75E-186	6,76E-05	0,12	3,70E-05	0,454
C	-0,3757	-0,043	-1	-1	0	6,75E-186	6,76E-05	0,12	3,70E-05	0,454
S	0,6745	0,1756	-1	-1	1	0	6,76E-05	0,12	3,70E-05	0,454
BF	-0,6831	-0,184	0,59	0,59	-0,6	-0,59	0	1,32 E-07	3,64 E-05	0,796
FF	0,1383	-0,088	0,25	0,25	-0,2	-0,25	0,72	0	0,28	0,586
PP	0,1563	-0,398	0,6	0,6	-0,6	-0,6	0,6	0,35	0	0,34
OP	-0,8196	-0,391	-0,12	-0,12	0,12	0,12	0,04	0,09	0,155	0

CS: Coarse sand, **FS** : fine sand, **C** : clay, **S** : silt, **RH :**Relative humidity,

Table 3: Correlations between soil chemical characteristics and trophic groups.

	EC	PH	P	K	OM	PP	BF	FF	OP
EC	0	0,08698	0,8985	0,12	0,29	0,4356	0,3488	0,60092	0,9284
PH	-0,38256	0	0,2877	0,806	0,23	0,3743	0,0919	0,46456	0,1718
P	-0,02966	-0,2434	0	0,3369	0,9484	0,5825	0,3509	3,33E-02	0,4463
K	-0,779	-0,1532	-0,5499	0	0,619	0,214	0,297	0,878	0,5
OM	0,45	-0,5	-0,45	-0,3043	0	0,263	0,01	0,03	0,637
PP	0,21524	0,37719	-0,214	-0,672	0,39	0	0,6918	0,96161	0,0047
BF	0,12114	-0,1688	-0,015	-0,404	0,35	0,3937	0	0,07743	0,8787
FF	0,17976	-0,2044	-0,127	0,588	0,18	0,5711	0,6919	0	0,4729
OP	0,020881	0,30977	-0,176	-0,096	7,68 E-2	-0,1657	0,5917	-0,0355	0

EC: Electrical conductivity, OM:organic material, P : Phosphore, K : potassium,

Discussion:

Our study of nematofauna associated with viticulture and represent ten vineyards in western Algeria reveals a significant diversity of sixteen genera of nematodes represented by: *Paratylenchus* sp., *Pratylenchus* sp., *Tylenchus* sp., *Tylenchorhynchus* sp., *Helichotylenchus* sp ., *Scutellonema* sp. and *Xiphinema* sp., *Aphelenchus* sp., *Aphelenchoides* sp., *Ditylenchus* sp., *Psilenchus* sp., *Cephalobus* sp., *Chiloplacus* sp., *Mononchus* sp. and *Dorylaimus* sp.

Our results on the inventory of nematodes on the vineyard are similar to those reported by Galet [16] on the French and Spanish vineyards, which demonstrated that the most feared nematodes on vines in France and which are the subject of several researches and publications belong to two groups:

The Tylenchides: contain four families: the Heteroderidae (genus *Meloidogyne* spp.), The Hoplolaimidae (*Pratylenchus* spp.). The Criconematidae with the genus (*criconemella* spp.) and the Tylenchulidae with the species (*Tylenchulus semipentrans*) (mi-sedentary - endoparasites of the roots).

The Dorylaimides: These nematodes cause little damage directly to the vine but their importance is considerable because they transmit some viruses of the vine through their bites. The Longidoridae family (*Xiphinema* and *Longidorus*) is the most interesting in this group.

According to Arias et al. [1], the genus *Xiphinema* is present on 70% of the samples taken from Spanish vineyards. The most replied species being X. index (first position), then *X. italiae* and *X. mediterraneum* and *X. diversicaudatum* and *X. rivesi*.

The overall assessment of the populations inventoried in the ten vineyards shows the dominance of the phytophagous group (35.689%) which represented mainly by eight genera: *Paratylenchus* sp., *Pratylenchus* sp., *Tylenchus* sp., *Tylenchorhynchus* sp., *Helichotylenchus* sp., *Scutellonema* sp. and *Xiphinema* sp. Compared to fungivorous (21.436%). In the second position, with the presence of *Aphelenchus* sp., *Aphelenchoides* sp., *Ditylenchus* sp. and *Psilenchus* sp. Followed by bacterivorous (21.436%) which represented by: *Cephalobus* sp., *Chiloplacus* sp. and *Rhabditis* sp. While omnivorous-predators (*Mononchus* sp. and *Dorylaimus* sp.) appear to be very poorly represented in all study stations. Indeed, several research studies indicate that nematodes are useful bioindicators in soil ecosystems [6, 12]. Predatory and omnivorous nematodes are the most sensitive to environmental perturbations [5, 18], while bacterivorous and fungivorous nematodes tolerate different chemical residue levels applied in conventional agriculture [15].

The analysis of results by using the General Linear Model (GLM) revealed a very highly significant difference in nematode densities ($P < 0.05$, $P = 0.000$) with nematode dominance, *Cephalobus* and *Dorylaimus* dominating in soil study stations. Significant differences were observed at study stations between the distribution of nematodes and trophic groups ($P = 0.026$ and $p = 0.001$, $P < 0.05$). Phytophagous and fungus-bearing plants abound in study stations, followed by bacterivorous, while omnivorous predators are the least represented, with L2 and L5 soils which hosting the largest amounts of nematodes.

These results are according to those founded by cadet [8] who demonstrated that the presence of plant doesn't determine the nematode species that are able to parasite it. For the same plant, the nematode species present in sandy soils are often different from those of clay soils [11]. Indeed, the variability of trophic groups observed in these different sites would be linked to various factors. According to Norton and Niblack [25], it is related to differences in species' life cycles, quality and availability of food's resources, biotic relationships with soil microorganisms, and physic and chemical factors in the environment.

The study's effect of the edaphic environment that allows the course of the telluric phase of the life cycle of the nematodes is demonstrated by Kandji et al. [29], which indicate that the physic and chemical properties of soil play an important role in the abundance, distribution and structure of nematode communities.

In this context, our results on correlations between soil's physical characteristics and trophic groups reveal that phytophagous and bacteriovorous nematodes are sensitive to high levels of silt and clay; whereas these two trophic groups multiply easily in sandy soils. These correlations are similar to those founded by Reddy [26] and indicate that sandy soils are most favorable to the development of phytophagous nematodes. On the other hand, clay soils strongly inhibit their outbreaks. There is some agreement by considering the texture and structure of the soil as relevant variables, since they affect the size of soil pores and the existence of stable compound aggregates. Coarse structures and well-structured soils are appropriate factors for faster population's growth [22, 2]. On the other hand, the correlations between the chemical characteristics of soil and the trophic groups are positive between the organic matter and the two groups bacterivorous and fungivorous insofar as they develop to the detriment of the bacteria or the fungi associated with the presence of organic matter [27] and these correlations are negative between the phosphorus content and the fungivorous group. In agreement with Steiner [28], these few studies suggest that soil pH is an unimportant ecological factor for nematodes. On the other hand, no effect was observed on the other characteristics (P and EC) on nematodes.

Conclusion:

The nematodes present themselves in communities (more or less) diversified according to the degree of anthropisation of the environment whatever the environment. To give an exhaustive account of diversity's nematofauna in an agro-vine system and the effect of edaphic environment on this distribution, our research was carried out in 10 stations in the west of the country.

This study allowed us to identify sixteen nematode genera in vineyard soils distributed according to their diet in four trophic groups: Phytophagous (*Paratylenchus* sp., *Pratylenchus* sp., *Tylenchus* sp., *Tylenchorhynchus* sp., *Helichotylenchus* sp., *Scutellonema* sp., and *Xiphinema* sp.) and Fongivorous (*Aphelenchus* sp., *Aphelenchoides* sp., *Ditylenchus* sp. and *Psilenchus* sp.) and Bacterivorous (*Cephalobus* sp., *Chiloplacus* sp. and *Rhabditis* sp.) and Omnivorous-Predators (*Mononchus* sp. and *Dorylaimus* sp.).

The General Linear Model (GLM) applied to the distribution of mean nematode abundances in ten vineyards in western Algeria, reveals significant differences between the distribution of nematodes and between trophic groups in study stations and a very highly significant difference at the densities of the nematodes. The group phytophagous and fungivorous abound in the study stations, followed by that of bacterivorous (with the most important nematode abundances are reported in stations L2 and L5). Concerning the average abundances of nematodes, *Cephalobus* and *Dorylaimus* dominate in the soils of the inventoried vineyards.

On the one hand the correlations between soil's physical properties and trophic groups reveal that phytophagous's and bacterivorous's nematodes are sensitive to high levels of silt and clay; whereas these two trophic groups multiply easily in sandy soils. On the other hand, the correlations between the soil's chemical characteristics and the trophic groups are positive between the organic matter and the two groups of bacterivorous and fungivorous but they are negative between the rate of phosphorus and the group of fungivorous.

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