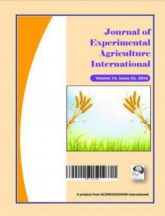

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Performance of Lettuce Cultivars of Inoculum of Nematode

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Authors' contributions

This work was carried out in collaboration between all authors. Author IDEC designed the study, performed the statistical analysis, wrote the protocol. Author JLSCF were the guided research. Authors CCAP and SMAOS contributed to the implantation, conduction and evaluation of the research. Author DSC contributed to the translation and standardization of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Lettuce is the hardwood vegetable that presents the greatest increase of consumption in Brazil, and therefore the most important for local horticulture. Because the intensity of cultivation, and the large area planting, some problems have worsened, especially issues related to pathogens such as nematodes of the species *Meloidogyne incognita*, which penetrate to the root AND CAUSING reduction in productivity. Existing cultivars on the market have more or less able to tolerate the nematodes attack, depending on growing conditions and climate conditions which are subject. In addition to these factors, the actual population of nematodes is a determining factor to harm the yield of lettuce. The cultivars used were Solaris©, Elba©, Amanda©, SRV 2005©, subjected to two of inoculum nematode *M. incognita*, 10,000 eggs / plant and 20,000 eggs / plant, and a control without the presence nematodes. The experimental arrangement used was the randomized block design in a factorial (4 x 3) with 4 replications. Plants were harvested 48 days after planting and evaluated the

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Fresh weight of shoots (FWS), Number of leaves (NS), Head diameter (HD), Stem diameter (SD), Stem length (SL), Fresh root mass (FRM), - Average number of eggs (ANE), and Reproduction factor (RF). Cultivar SRV 2005 has the potential to be used in areas with the presence of *Meloidogyne incognita* (race 1), and can be used as a potential source of resistance to the pathogen. The initial innoculation of eggs did not affect the interaction of the genotype with the final concentration of *Meloidogyne incognita* eggs (Race 1). The initial number of 20,000 eggs promoted a higher average number of eggs at the end of the crop cycle, but the reproduction factor presented a decrease in the final number of eggs with approximately 14,000 units.

Keywords: Lactuca sativa L.; Meloidogyne incognita; population of nematodes.

1. INTRODUCTION

The lettuce (*Lactuca sativa* L.) is the most consumed leafy vegetable in Brazil, presenting within the specie, the curly types, smooth, american mimosa and roman, thus meeting the various market segments. Producing regions of lettuce are located close to large consumer centers, normally, this activity is developed by small farmers, due to the intensive need for input and labour, thus the growing areas are then exploited for years, a factor that facilitates the occurrence of pests and diseases [1,2]. When the lettuce is grown, new seeds must be used, because lettuce seeds stored at high temperatures will have lower germination and longevity [3]. In addition to the use of quality seeds, it is also necessary to know the quality of the irrigation water, since the use of increasing levels of salts in irrigation water influences the development of lettuce (*Lactuca sativa* L.) cultivars, linearly decreasing the fresh weight, dry mass of shoot, number and dry mass of the root [4].

Nematodes are the pathogens that cause more damage to lettuce, they are obligatory parasites of various direct damage to the subterranean organs of certain vegetables by introducing their STYLET into the cell wall [1,5].

The severity of damage caused by nematodes depend, on the genotype of the plant, nematode gender, number of nematodes in the soil, in addition to environmental conditions, and the population of nematodes in the soil a major, the species of the nematode, depending on the relationships of these factors, the productivity of the crop can be reduced. However, excessive nematodes in the soil does not necessarily imply greater damage the crop, since the nematodes themselves may compete with each other for growth factors [6].

The commercial cultivars to succeed must have resistance to nematodes such as *Meloidogyne incognita*, *M. javanica* among others, as the cultivar Salinas 88 resistant to both genders [7]. However, it is important to evaluate novo commercial cultivars to be able to recommend them according to environmental conditions and type of soils.

The damage of the nematode galls on lettuce will depend on the interaction of plant genotype with the pathogen, depending on the environmental conditions, thus it is crucial to know either the behaviour of each genotype environment, which also encompasses the culture system and from the this information suggest possible materials for cultivation in the region or determine possible commercial sources of resistance [8].

The aim of this study was to evaluate the behaviour of lettuce cultivars subjected to of inoculum of root-knot nematodes (*M. incognita* race 1).

2. MATERIALS AND METHODS

The experiment was conducted in the Department of Agronomy, plant science Area Rural Federal University of Pernambuco, Campus two Brothers, Recife-PE on summer; being held in this greenhouse with 30 m long, 14 m wide, 3 m right foot, with lateral protection screens 50% shading and roof covered with low density polyethylene film of thickness 150 microns.

The cultivars were Solaris (Seminis®), Elba (Top Seed Garden®), Amanda (Seminis®), SRV 2005 (Seminis®), were treated with two of inoculum nematode *M. incógnita* R1 10,000 eggs/plant and 20,000 eggs/plant, and a control without the presence nematodes.

The experimental design was casulizados blocks in factorial (4 x 3), four concentrations and three

cultivars inoculum in four blocks. Each experimental plot consisted of four lettuce plants grown on the tray and transplanted into 5 L polyethylene vessel at 10 days after planting. The substrate used was coconut powder, which received the hydroponic solution for lettuce 2,000 liters: 2.350 g of Calcium Nitrate, 1.465 g of Potassium Nitrate, 585 g of MKP, 1197 g of Magnesium Sulfate, 68 g Quelatec, 68 g of Ultra Ferro and 177 ml of Boric Acid. Irrigation was performed in 6 rounds irrigation interval of two hours, with duration of four minutes.

The inoculation with nematodes occurred 5 days after transplanting using a syringe pistol 50 cc for applying the solution containing the nematodes concentration (2000 eggs/ml). After inoculation, the irrigation was monitored for 4 days, to avoid detachment of nematode eggs.

Plants were harvested 48 days after planting, in which the characteristics were evaluated: Fresh weight of shoots (FWS), Number of leaves (NS), - Head diameter (HD), Stem diameter (SD), Stem length (SL), Fresh root mass (FRM), - Average number of eggs (ANE), and Reproduction factor (RF).

The statistical analysis used were ANOVA, Tukey test at 5% probability level for comparison of cultivars, polynomial regression of inoculum. Pearson's correlation was used to identify the variables that have association.

3. RESULTS AND DISCUSSION

According to the F test at 5% probability, no significant difference in the interaction between the cultivars with the initial nematode inoculum, showing independence in each factor.

In Table 1 are the averages of the characters of lettuce genotypes, wherein according to Tukey's test at 5% probability can be concluded:

For the fresh weight of aerial part (FWS), head diameter (HD), average number of eggs (ANE) and the reproduction factor (RF), the genotypes showed no significant difference, with respective mean, 365.61 g, 47, 05 cm 17024.57 units. and 1.15.

Elba genotype showed higher number of leaves (NL) (21 un.), no statistical differences Amanda and Solaris genotypes with respective averages 16.33 and 19.00 units., differing between both SRV 2005 with an averaging 14.44 leaves.

For the variable stem diameter, Elbe genotype larger diameter of the stem (SD) (25.25 mm) did not differ statistically, Solaris Amanda (23.63 and 24.76 mm). For stem length (SL) genotype showed the greatest length Elbe, 14.33 differing from the other genotypes. The SRV 2005 genotype showed lower DC.

Elba genotype showed the highest fresh weight of root (FRM) (49.27 g) Solaris not statistically different genotype (40.53 g). Amanda and the SRV 2005 genotypes had the lowest fresh root, averaging respective 34.05 g and 38.78 g. The level of the inoculum used in an experiment to verify the reaction of cultivated species to nematodes is also an important factor, and it is essential to study the most indicated concentration [9].

Infested plants by nematodes have less developed due to dense gall formation on the root system, and these in turn hinder the uptake of water and nutrients, resulting in yellow plants with head and small size, in addition to small leaf volume [10]. But the cultivation environment has a great influence on the negative effect caused by the nematode, so that the very culture system can serve as a control to reduce the population of nematodes, as in this study, in which the substrate used was coconut powder system hydroponic, thus minimising the harmful effects of the pathogen [11,12].

Table 1. Average of characters of lettuce genotypes

Genotypes	FWS	NL	HD	SD	SL	FRM	ANE	RF
Amanda	340,52a	16,33ab	47,22a	23,63ab	7,93b	34,05a	15173,88a	1,11a
Elba	448,26a	21,00b	46,38a	25,25b	14,33c	49,27b	23389,66a	1,58a
Solaris	405,33a	19,00ab	47,22a	24,76b	8,86b	40,53ab	17309,11a	1,13a
SRV 2005	365,61a	14,44a	47,38a	20,90a	5,80a	39,78a	12227,11a	0,84a
Average	389.93	-	47.05	-	-	-	17024.94	1.17
Δ (5%)	108.93	5.81	2.02	3.02	1.89	8.94	11514.57	0.88

Columns followed by the same letter in column are not statistically different by Tukey test at 5% probability. FWS - Fresh weight of shoots (g); NS - Number of leaves (un.); HD - Head diameter (cm), SD - Stem diameter (cm); SL - Stem length (cm); FRM - Fresh root mass (g); ANE - Average number of eggs (un.); RF - Reproduction factor (dimensionless)

The reproduction factor (RF), was not significantly among genotypes, with an average of 1.17, but the Elbe genotype showed higher average number of eggs (ANE), un 23389.66, About 48% more than the SRV 2005 genotype, 35% to more than 26% and Amanda genotype more than the Solaris thus the SRV 2005 genotype showed the lowest RF, 0.84, being potentially resistant to *Meloidogyne incognita* (race 1), since it reduced the reproduction of the pathogen.

Second Melo et al. [13] and Ferreira et al. [14], genotypes that RF less than 1, have a resistance level, because it decreases the exponential population growth, thus the study the SRV 2005 genotype decreased the number of eggs in relation to the average number of eggs, showing the potential thereof for It is used in areas with the presence of *Meloidogyne incognita* (Race 1), and the use of the cultivar as resistance source for breeding programs.

Table 2 shows the average of lettuce variable depending on the of *Meloidogyne incognita* eggs (race 1). The of eggs did not influence the FWS, NS, HD, SD, SL and FRM with respective averages 389.60 g, 17.69 leaves, 47.06 cm, 23.30 mm, 9.27 cm and 40 91 g.

ANE was directly influenced by the increased initial number of eggs in that as the initial number of eggs increased, the final was high, being represented by the equation: y = 494,69 + 1.653,02 x (R^2= 99,73), and can be observed by the pet this characteristic Fig. 1. Similarly, the RF was influenced by the initial number of eggs, can be estimated by the equation y = 0,00 + 0,30x – 0,011x^2 (R^2 = 100), the evaluation of *Meloidogyne incógnita* requires the adoption of an efficient, rapid and practical method so that large populations of plants can be analysed in a short time [15].

Initial number eggs showed no loss in qualitative and quantitative terms, so that even with increased initial of eggs, it is lettuce not reduced productivity and lost no commercial value, contrasting what [16] it is reported in their work, using the cultivar Vitoria de Santo Antão, that the greater the of nematodes in the soil, the greater were productivity losses, thus the hydroponic system, shown as an alternative in areas where soils have high nematode infestations.

In Chart 1, we can observe the behaviour of the average number of eggs and reproduction factor depending on the initial number of eggs, in which it can be concluded that the average number of eggs was influenced diretamentand the starting number, but the reproduction factor grew to about 14,000 eggs, after this, there was a decrease in reproduction factor, indicating that the nematodes began to compete with each other by the lettuce roots, a fact reported by the SBN [17], in which there can be competition among different species of nematodes, but also from the same species, depending on the population of nematodes in root environment.

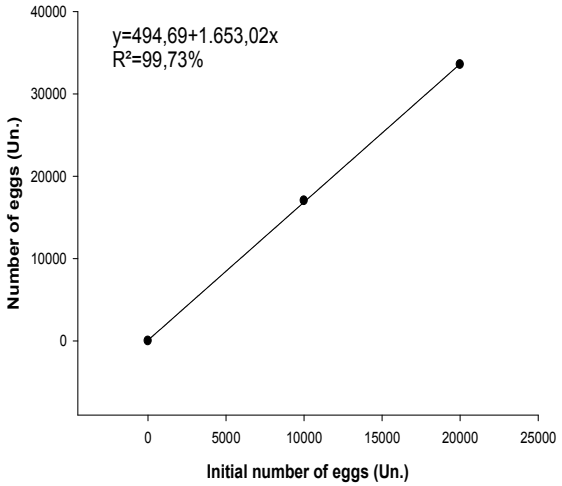
The traits evaluated showed low relationship between the traits, the most significant relationship between the FWS and SD (0.60) and the FRM with the RF (0.44). Thus, the FRM presented a relationship with FWS (0.55). But due to low expression of the associations between the characters studied, it can be concluded that for the genotypes studied can not make a prediction of the nematode population in terms of agro-morphological characters.

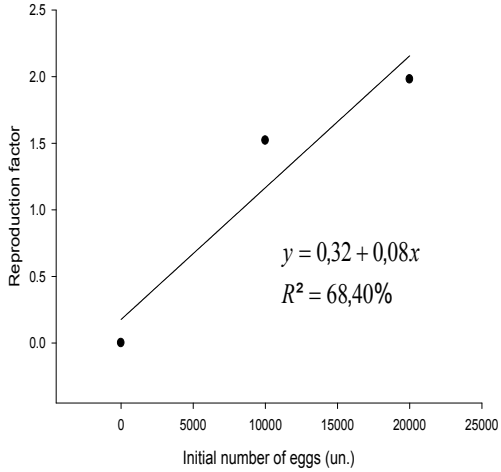
In hydroponic systems, where the nutritional status of the plant is dependent on the nutrient solution, then the presence of the nematode does not influence the characteristics of lettuce, justifying this way, the non-occurrence correlation between the characters on the plant and the presence of nematodes in plants, differing thus from the results found by

Table 2. Mean and regression equations of lettuce characters depending on the concentration of *Meloidogyne incognita* eggs

Eggs	FWS	NS	HD	SD	SL	FRM	ANE	RF *
0	386.63	19.08	47.00	24.43	9.60	37.01	0.00	0.00
10,000	387.93	16.62	47.17	23.04	9.70	41.96	17024.94	1.52
20,000	394.23	17.37	47.00	23.44	8.38	43.76	33555.20	1.98
Average	389.60	17.69	47.06	23.30	9.27	40.91	-	-
Equation	-	-	-	-	-	-	y = 494.69 + 1653,02x	y = 0.32 + 0,08x
R^2	-	-	-	-	-	-	99.73	100

** -Value of x divided by 1000. FWS - Fresh weight of shoots (g); NS - Number of leaves (un.); HD - Head diameter (cm), SD - Stem diameter (cm); SL - Stem length (cm); FRM - Fresh root mass (g); ANE - Average number of eggs (un.); RF - Reproduction factor (dimensionless)*





Figs. 1 and 2. Estimate of the final number of eggs and reproduction factor depending on the initial number of eggs

Table 3. Pearson's correlations between the lettuce characters

Characteristics	FWS	HD	NS	SL	SD	FRM	ANE
HD	-0.13						
NS	0.47 **	0.07					
SL	0.60 **	-0.22	0.57 **				
SD	0.52 **	-0.04	0.58 **	0.67 **			
FRM	0.55 **	-0.03	0.34 *	0.53 **	0.13		
ANE	0.27	-0.08	0.07	0.13	-0.02	0.46 *	
RF	0.28	-0.06	0.03	0.18	-0.04	0.44 **	0.89 **

FWS - Fresh weight of shoots (g); NS - Number of leaves (un.); HD - Head diameter (cm), SD - Stem diameter (cm); SL - Stem length (cm); FRM - Fresh root mass (g); ANE - Average number of eggs (un.); RF - Reproduction factor (dimensionless)

Table 4. Analysis of Variance of performance of lettuce cultivars to different nematode populations

Source of variation	GL	QM							
		FWS	FNE	HD	SD	SL	FRM	ANE	RF
Cult	3	20017,25^{ns}	75.13*	1,83^{ns}	34.09**	118.93**	354.98**	1822,30^{ns}	0,11^{ns}
Pop	2	257,35^{ns}	19,05^{ns}	0,11^{ns}	6,16^{ns}	6,49^{ns}	146,92^{ns}	101,102.39**	6.53**
GXP	6	7925,72^{ns}	6,16^{ns}	1,22^{ns}	3,44^{ns}	2,03^{ns}	15,69^{ns}	1098,21^{ns}	0,06^{ns}
Blocks	2	8753.45	23,05	0.63	0.50	3.98	64.84	1373.19	0.08
Residue	22	6923.29	19,70	2.38	5.32	2.09	46.70	816.86	0.06
CV (%)		21.34	25.09	3.29	9.76	15.69	16.70	27.90	29.59

FWS - Fresh weight of shoots (g); NS - Number of leaves (un.); HD - Head diameter (cm), SD - Stem diameter (cm); SL - Stem length (cm); FRM - Fresh root mass (g); ANE - Average number of eggs (un.); RF - Reproduction factor (dimensionless)

Silva et al. [11], evaluating different chemical and organic fertilisers on nematode control in lettuce under protected cultivation observed that there is a correlation between the number of eggs and fresh pasta plant, showing that the soil biological dynamics of nematode negatively lettuce.

According to Carvalho et al. [18], the characters related to nematodes such as galls incidence, the number of galls and the number of egg have great influence of the environmental characteristics in the expression of the phenotype, in this way, in the present study, the conditions of cultivation were determinant so that even with the attack of the nematodes, the agro-morphological characteristics were not influenced, and for that reason, the low relation between the characters studied.

According to the at F 1% probability of a source of large variation of SD, SL and FRM, a difference of 5% was for FNE and there was no significant difference for an FWS, HD, ANE and RF. For the nematode population, there was a 1% probability difference for ANE and RF, and there was no significant difference at 5% probability for the other variables. For the interaction G x P, there was no significant difference at 5% probability for any of the variables, that is, the cultivars were not influenced by the nematode population.

4. CONCLUSION

Cultivar SRV 2005 It showed a decrease of the number of eggs of *Meloidogyne incognita* (Race 1).

The initial number of eggs did not influence the interaction of genotypes with the final of egg *Meloidogyne incógnita* (Race 1).

The initial number of 20,000 eggs provided a higher final number of eggs, but the reproduction rate decreased with approximately 14,000 eggs of the initial.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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