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Multivariate analysis as a tool in the selection of sustainable melon agroecosystems in the semi-arid region

Análise multivariada como ferramenta na seleção de agroecossistemas sustentáveis de cultivo de meloeiro no Semiárido

Alessandra M. Salviano[1]*, José M. da C. Castro[1], Stefeson B. de Melo[2], Márcia V. de Macedo[3], Vitória R. Oliveira[3], Vanderlise Giongo[4]

[1]Embrapa Semi-Arid, Empresa Brasileira de Pesquisa Agropecuária, Petrolina, PE, Brazil. [2]Department of Exact, Tecnological and Human Sciences, Universidade Federal Rural do Semi-Árido, Angicos, RN, Brazil. [3]Departament of Biological Sciences, Universidade de Pernambuco, Petrolina, PE, Brazil. [4]Embrapa Wheat, Empresa Brasileira de Pesquisa Agropecuária, Passo Fundo, RS, Brazil.

ABSTRACT - Soil management systems, including tillage and green manuring, are important for the control of nematodes and for the sustainable production. The objective was to select, through multivariate analysis, sustainable agroecosystems for yellow melon cultivated under irrigated conditions in the Brazilian semi-arid region. The long-term experiment is set up in *Argissolo Vermelho-Amarelo* (Ultisol) with six multifunctional agroecosystems, composed of the combination of three mixtures of cover crops (1 - 75% legumes + 25% grasses and oilseeds; 2 - 25% legumes + 75% grasses and oilseeds and 3 - spontaneous vegetation) and two types of soil management (no tillage-NT and tillage-T). The purpose was to evaluate the nutritional status of plants, soil fertility, nematode population in roots and soil, and the yield. Data were analyzed with multivariate techniques, allowing the grouping of the agroecosystems based on their similarities and complexity of functions. The incorporation of plant residues to the soil reduces nematode population, but their maintenance on the surface allows the improvement of fertility and yield, even under larger nematode populations. The agroecosystems that associate the non-incorporation of residues from cover crops with larger species diversity in composition constitute the most complex model, allowing different environmental functionalities. Thus, it is recommended not to incorporate the plant residues, planting the melon seedlings directly in the straw. However, considering that the results obtained with the non-incorporation of spontaneous vegetation were similar to those obtained with the incorporation of commercial cover crops, it is concluded that this practice is also viable and adapted to the semi-arid conditions.

Keywords: Green manure. Soil turning. Spontaneous vegetation. *Cucumis melo*. Phytoparasitic nematodes.

RESUMO - Sistemas de manejo de solos, incluindo revolvimento e adubação verde, são importantes para o controle de nematoides e para a produção sustentável. Objetivou-se selecionar, por meio da análise multivariada, agroecossistemas sustentáveis para cultivo irrigado de melão amarelo no Semiárido brasileiro. As avaliações ocorreram num experimento de longa duração, com seis agroecossistemas multifuncionais, compostos pela combinação de três misturas de plantas de cobertura (1 - 75% leguminosas + 25% gramíneas e oleaginosas; 2 - 25% leguminosas + 75% gramíneas e oleaginosas e 3 - vegetação espontânea) e dois tipos de manejo do solo (sem e com revolvimento). Avaliaram-se o estado nutricional das plantas, a fertilidade do solo, as populações de nematoides nas raízes e no solo e a produtividade da cultura. Os dados foram submetidos às técnicas de análises multivariadas, permitindo agrupar os agroecossistemas por semelhanças e complexidade das suas funções. A incorporação dos resíduos vegetais ao solo reduz a população de nematoides, mas sua manutenção na superfície permite melhorar a fertilidade e alcançar boas produtividades, mesmo sob maior população de nematoides. Os agroecossistemas que associam o não revolvimento dos resíduos vegetais das plantas de cobertura com maior diversidade de espécies na composição é o modelo considerado mais complexo, permitindo diferentes funcionalidades ambientais. Assim, recomenda-se não incorporar os resíduos vegetais, transplantando as mudas de meloeiro diretamente sobre a palhada. No entanto, considerando que os resultados obtidos com a não incorporação da vegetação espontânea foram semelhantes à incorporação das plantas de cobertura comerciais, conclui-se que esta prática também é viável e adaptada às condições semiáridas.

Palavras-chave: Adubação verde. Revolvimento do solo. Vegetação espontânea. *Cucumis melo*. Nematoides fitoparasitas.

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***Corresponding author:**
<alessandra.salviano@embrapa.br>

INTRODUCTION

In the Brazilian semi-arid region, irrigated agriculture, which covers more than 1.2 million hectares, has developed through public policies and economic incentives to support regional development (BRASIL, 2017). Thus, in recent decades, the Caatinga vegetation has been replaced with monocultures. In addition to the impacts caused by irrigated agriculture, this biome is also affected by livestock farming and logging activities. These activities favor the imbalance in carbon (C) fluxes, since the Caatinga is an important sink of atmospheric C, even in periods with prolonged droughts (MENDES et al., 2020).

In this region, the production systems of vegetables, such as melon (*Cucumis melo* L.), in irrigated monoculture, with intensive use of fertilizers and soil turning, can accelerate the mineralization of C, mainly due to the predominance of sandy soils and high temperatures and humidity, accentuating the emission of greenhouse gases. Therefore, these production models may be associated with physical, chemical and/or biological degradation of the soil, intensifying salt, water and thermal stresses, typical of arid and semi-arid regions (SILVA et al., 2014; SANTOS et al., 2018a; BARROS et al., 2019; RASHIDI et al., 2019; CASTRO; SANTOS, 2020; VIZIOLI et al., 2021). In addition to these impacts, there is also the incidence of pests and diseases, especially nematodes, which cause great damage to crops (FERRAZ; BROWN, 2016).

Thus, considering the need to produce food, reduce the impacts of anthropic activities on the environment and stimulate sustainability, the aim was to develop models of agroecosystems adapted to the conditions of the semi-arid region (GIONGO et al., 2021). One of these models has simultaneous cultivation of different cover crops associated with the no-tillage melon, whose proposal is multifunctionality, in opposition to the vegetable production systems currently adopted in the semi-arid region, based on monocultures and with heavy use of chemical inputs.

These sustainable multifunctional agroecosystems, among other benefits, make it possible to increase soil C stock (GIONGO et al., 2017; 2020). Long-term simulations showed that not turning the soil and using cover crops with high biomass production would allow these stocks in melon production systems to reach, within 20 years, values similar to those observed in preserved Caatinga (GIONGO et al., 2020). Furthermore, the increase in biodiversity (FREITAS, 2018; SILVA; GIONGO; LIMA, 2021) and the provision of other ecosystem services (SANTOS et al., 2018a; DEUS et al., 2022) are benefits observed.

However, to date, the proposed agroecosystems have not been evaluated in an integrated way with respect to soil and plant compartments and management of diseases, so as to allow inferring about their benefits for the sustainability of the melon production process in the semi-arid region. Thus, the objective was to identify, through multivariate analysis, integrating data of soil fertility, plant nutritional status, nematode infestation and yield, the main functionalities of agroecosystems to assist in the selection of alternatives to the conventional melon cultivation system that allow the sustainability of the crop in the Brazilian semi-arid region.

MATERIAL AND METHODS

Characterization of the area

The study was carried out in a long-term experiment that began in 2012, in the Bebedouro Experimental Field (9°08' S, 40°8' W, 365.5 m altitude), belonging to Embrapa Semi-arid (Brazilian Agricultural Research Corporation) and located in the municipality of Petrolina, PE, Brazil (Figure 1). The soil of the area was classified as *Argissolo Vermelho-Amarelo eutrófico plíntico* (Ultisol) (SANTOS et al., 2018b), with medium/clayey texture and flat relief. The climate is semi-arid, classified as BSwh', according to the Köppen system, with an average annual temperature of 26.8 °C, average annual precipitation of 360 mm, and the native vegetation is Caatinga type.

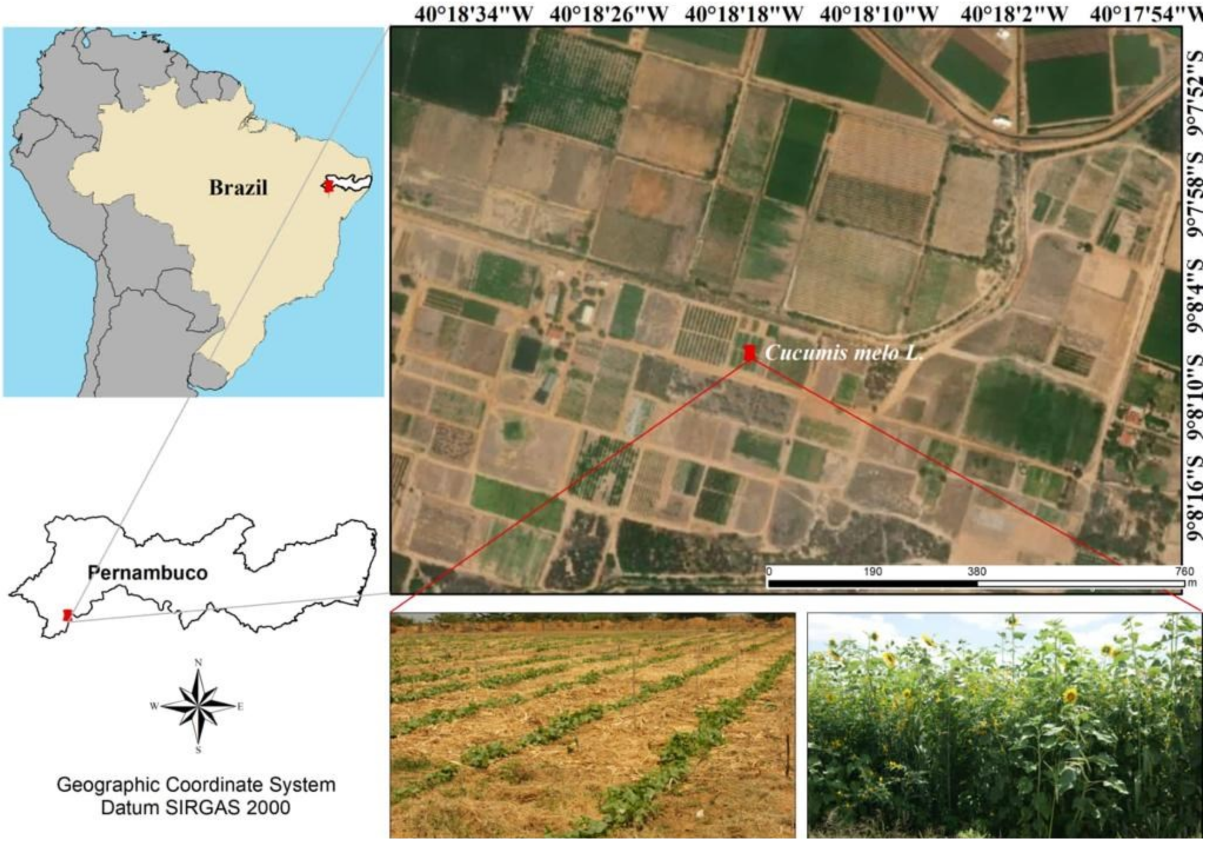

Figure 1. Location of the experimental area in Petrolina, Pernambuco, Brazil.

Treatments and experimental design

The experimental design was randomized blocks in split plots. The plots consisted of two types of soil management: no-tillage (NT) and tillage (T), and the subplots consisted of the three types of soil cover: mixture of plants 1 (75% legumes + 25% grasses and oilseeds); mixture of plants 2 (25% legumes + 75% grasses and oilseeds) and mixture of plants 3 (spontaneous vegetation).

Plant mixtures are composed of the combination of quantities of seeds to achieve the stipulated proportions of legume, grass and oilseed species (Table 1). The species used are: *Calopogonium mucunoides* Desv., *Stizolobium aterrimum* Piper & Tracy, *Mucuna cochinchinensis* (Lour.) A. Chev., *Crotalaria juncea* L., *Crotalaria spectabilis* Roth, *Canavalia ensiformis* (L.), *Cajanus cajan* (L.), *Dolichos lablab* L., *Zea mays* L., *Pennisetum americanum* (L.), *Sorghum vulgare* Pers., *Sesamum indicum* L., *Ricinus communis* L. and *Helianthus annuus* L.

In the spontaneous vegetation, *Commelina benghalensis* L., *Commelina difusa* Burm. F., *Macroptilium atropurpureum* Urb., *Digitaria bicornis* (Lam.) Roem. Schult., *Dactyloctenium aegyptium* (L.) Willd., *Macroptilium lathyroides* (L.) Urb., *Desmodium tortuosum* (Sw.) DC. and *Acanthospermum hispidum* DC., *Euphorbia chamaeclada* Ule, *Waltheria rotundifolia* Schrank, *Waltheria* sp. L., *Tridax procumbens* L., *Ipomoea mauritiana* Jacq., *Ipomoea bahiensis* Willd. Ex Roem. Schult. and *Amaranthus deflexus* L. were the predominantly identified plants.

Table 1. Quantities of seeds used in the composition of mixtures of cover crops sown between rows of melon crop.

Cover crops	1*	2
	kg ha^{-1}	
Legumes		
Cajanus cajan (L.) Millsp. (Pigeon pea)	12.7	4.2
Calopogonium mucunoides Desv. (Calopo)	3.7	1.2
Canavalia ensiformis (L.) DC. (Jack bean)	187.5	62.5
Crotalaria juncea L. (Brown hemp)	13.5	4.5
Crotalaria spectabilis Roth (Showy rattlebox)	5.5	1.7
Dolichos lablab L. (Lablab bean)	60.0	20.0
Mucuna cochinchinensis (Lour.) A. Chev. (Velvet bean)	101.2	33.7
Mucuna pruriens Piper & Tracy (Velvet bean)	101.2	33.7
Grasses		
Pennisetum americanum (L.) Leeke (Millet)	1.0	3.0
Sorghum vulgare Pers. (Sorghum)	2.5	7.5
Zea mays L. (Maize)	15.0	45.0
Oilseeds		
Helianthus annuus L. (Sunflower)	3.1	9.3
Ricinus communis L. (Castor bean)	30.0	90.0
Sesamum indicum L. (Sesame)	1.0	3.0

*1 (75% legumes + 25% grasses and oilseeds) and 2 (25% legumes + 75% grasses and oilseeds).

The plots were set up with 10 m length and 10 m width. In this area, 198 melon seedlings are transplanted annually at spacing of 2.0 m x 0.3 m.

The seeds of the mixtures of cover crops are sown annually in July, in furrows with spacing of 0.5 m. Approximately 70 days after sowing, the plants are cut 5 cm above the soil surface. In plots without soil management, the phytomass is deposited on the surface by cutting with manual mower and, in plots with soil management, the phytomass is incorporated to 20 cm depth through plowing and harrowing.

Melon planting

Yellow melon (cv. Gladial) is sown every year in October in polystyrene trays using commercial substrate and kept in a greenhouse for 12 days. After this period, the seedlings are transplanted to the field, and then the plant mixtures that make up the treatments are cultivated and managed. Fruit harvesting was performed 65 days after transplanting.

Experimental evaluations

Samples of the third leaf from the apex were collected, during the flowering period, to evaluate the nutritional status of the plants. Contents of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), zinc (Zn), copper (Cu), iron (Fe) and manganese

(Mn) were determined.

After harvest, soil samples were collected at 0-20 cm depth in all experimental units to determine the following chemical characteristics: total organic carbon (C), aluminum (Al^{3+}), exchangeable calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}) and sodium (Na^{+}), available phosphorus (P), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn); potential acidity (H+Al); electrical conductivity (EC) and pH in water (1:2.5) (TEIXEIRA et al., 2017). These results were then used to calculate cation exchange capacity (CEC), sum of bases (SB) and base saturation (V). At the same time, soil and root samples were collected at the same depth and in all experimental plots, in the melon rhizosphere, for identification and quantification of nematodes. The soil samples, in 100 cm^3 aliquots, were processed by the method of Jenkins (1964). The root samples, in 10 g portions, were fragmented into segments of about 1 cm and processed by crushing in water in a blender, according to the method of Coolen and D'Herde (1972), modified by the non-addition of kaolin. Then, 1 mL aliquots were placed in Peters' chamber for the quantification of nematodes under a light microscope with 100x magnification, taking the average of two counts per sample. The identification of nematodes, in genus (MAY; MULLIN, 1996), was made under light microscope, with 100, 400 or even 1000x magnification.

Statistical analysis

To find the most important variables and their relationships, principal component analysis (PCA) and factor analysis (FA) were performed, considering only the most relevant components, with accumulated variance above 70% (HAIR JUNIOR et al., 2009) from the analysis of screen-plots (PAYE; MELLO; MELO, 2012). The criterion adopted to exclude the variables in the two analyses was to select those with absolute value above 0.65 (ARCOVERDE et al., 2015). PCA was used as exploratory analysis to reduce the number of variables. FA used the extraction by PCA, and the factors were rotated by the varimax method.

The clustering followed the hierarchical method, using the Euclidean distance as a measure of similarity between the records and Ward's method as a clustering strategy. Only the significant variables in the first two factors of FA were used for cluster analysis. To reduce errors, due to the scales and units of the variables, the data were standardized with mean zero and variance one (FREITAS et al., 2014). Then, the Fenon Line was drawn horizontally to determine the number of clusters formed. Based on the objective of the study and on the available references, the line was drawn at 20% for all clusters formed, since the Ward's method allows the cut between 20% and 30%.

After determining the number of clusters formed, it was possible to infer about the similarities or differences between the managements adopted in the soil and the mixtures of cover crops used, with respect to soil quality, plant nutritional status and nematode population.

Multivariate analysis of variance was performed to compare the clusters formed in the cluster analysis, using the Roy's test ($p < 0.05$).

RESULTS AND DISCUSSION

Principal Component Analysis (PCA)

From the results of the PCA, it was observed that components 1 (PC1), 2 (PC2), 3 (PC3) and 4 (PC4) explained 34.57, 22.01, 19.58 and 14.55% of data variability (Figure 2).

The variables with the highest weight in PC1 were the populations of *Criconema* in the soil, *Meloidogyne* and *Pratylenchus* in the roots, total population of nematodes in the roots, the chemical characteristics EC and V, contents of C, Na, H+Al, Cu and Zn, and leaf contents of P, K and S, indicating that these were the ones which showed the highest variation as a function of the characteristics of the agroecosystems evaluated. PC2 had, as most important variables, marketable yield (MY), *Meloidogyne* population and total population in the soil, CEC and SB values, P and Mg contents and leaf contents of B and Na. The most important variables in PC3 were non-marketable and total yields and *Xiphinema* population in the soil, K and Mn contents in soil and leaf contents of N and chlorophyll a. The Fe content in the soil and the leaf content of Mn were considered as the most important variables in PC4. In Figure 2, the agroecosystems that use the tillage strategies, regardless of the proportion between the amounts of legumes and grasses used (T1, T2) and mowing of the spontaneous vegetation (NT3), showed a tendency to higher MY and higher contents of P, Mg and Mn in leaves and P in the soil. However, the populations of *Criconema* in the soil, *Meloidogyne*, *Pratylenchus* and the total population of nematodes in the roots, and the leaf contents of K, S, Fe and chlorophyll b were lower.

The practice of turning green manure residues promotes faster release of nutrients in the soil (FREITAS et al., 2019), increasing their availability to plants, which may result in yield increments. However, this rapid availability is not always advantageous, as it may lead to lower efficiency of nutrient use in the system, depending on soil characteristics such as texture, type of management and synchronization of nutrient release by the straw with crop requirement. This trend can be observed by the higher leaf contents of P and lower leaf contents of K and S, which are more mobile nutrients in the system. K is the nutrient with the highest decomposition speed, regardless of the type of plant mixture used, which is accentuated by soil turning (FREITAS et al., 2019; PEREIRA FILHO et al., 2019).

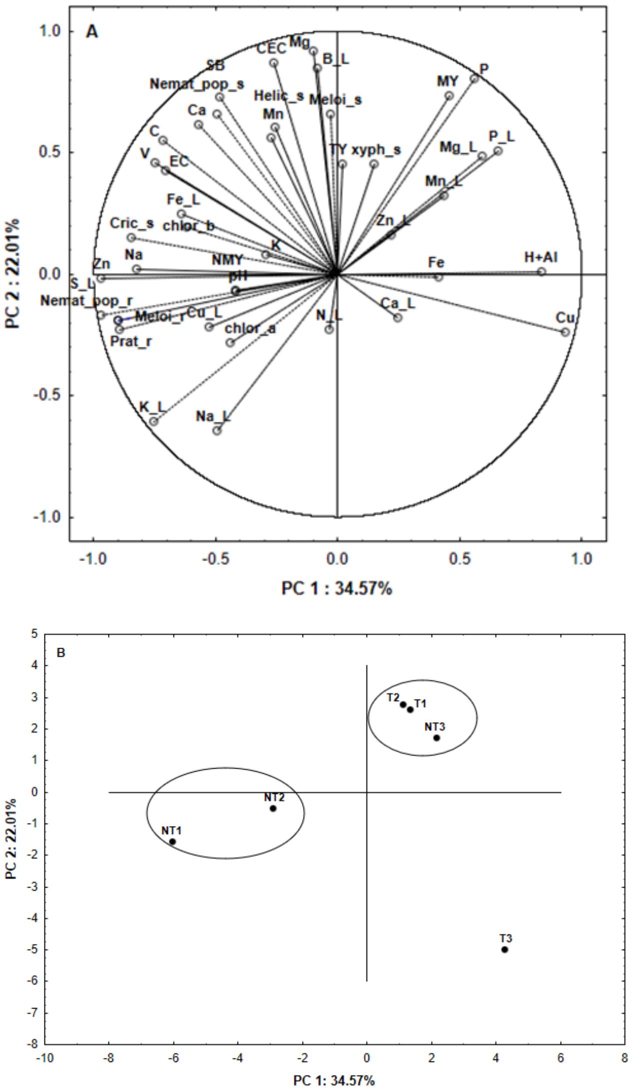

Figure 2. Graphs of the principal components (PC1 and PC2) for nematode population, yields, soil chemical characteristics and nutritional status of 'Gladial' yellow melon cultivated in multifunctional agroecosystems in the Brazilian semi-arid region.

Faster straw mineralization also reduces C supply in the soil and its advantages for long-term sustainability of the production system (GIONGO et al., 2020). However, this management also allows the practice of soil solarization, facilitating the control of nematodes, despite the previously commented loss of C.

The agroecosystems that recommend not turning soil, regardless of the proportion between the amounts of legumes and grasses used (NT1, NT2), showed contrary behavior with regard to the characteristics described for the previous cluster. Moreover, the larger population of nematodes in melon roots increased the production of fruits without quality for marketing and, consequently, marketable yield was negatively impacted, although no considerable reduction in total yield was observed. Nevertheless, these agroecosystems have, as main advantage, the improvement of soil chemical quality, especially regarding the C contents in the soil and the slower release of nutrients in the system, increasing the efficiency of cycling. The T3 agroecosystem, which uses spontaneous vegetation associated with soil turning, has the lowest degree of complexity of functions, showing the worst performance in terms of total yield and contents of exchangeable bases and C in the soil. However, higher Cu contents in the soil and smaller nematode populations in the soil and melon roots were observed.

Factor Analysis (FA)

After PCA, the following variables were removed from the database to generate FA: *Helicotylenchus* and *Xiphinema* populations, pH, Ca contents in the soil, as well as leaf contents of Ca, Mg, Cu, Fe and chlorophyll b.

The columns of the matrix refer to the rotated factor loadings for each of the variables analyzed (Table 2). The eigenvalues indicate the relative importance of each factor in explaining the variance associated with the set of variables analyzed. When significant factor loadings with opposite signs are obtained, a joint variation occurs, but in the opposite direction. Factor 1 is mainly represented by the populations of *Criconema* in the soil, nematodes in the roots, by the contents of P, H+Al, Cu and Zn in the soil and the contents of K and S in the leaf tissue. This factor explains the largest part of total variance of the data, with 38.31% (Table 2). Factor 2 was composed of the total population of nematodes in the soil, the C and Mg contents, the values of SB, CEC and V of the soil, in addition to the leaf content of B, explaining 24.45%; factor 3 explained 18.06% of the total variance of the data and was represented by total and non-marketable yields, the contents of K in the soil and the contents of N and P in the leaf tissue. Factor 4, responsible for 13.06% of the data variance, was composed of the *Meloidogyne* population in the soil, Fe contents in the soil, in addition to the leaf contents of Mn, Zn and Na.

Factors 1 and 2 together explained 62.76% of the data variance and are mainly represented by nematode populations in soil and roots and the variables that represent the exchange complex, which are the main differences observed between the agroecosystems and the variables that should be used as indicators of soil quality.

Table 2. Matrix of factor loadings after orthogonal rotation by varimax method.

Variables	Factor Loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
Yield (t/ha)				
Marketable[1]	-0.644	0.585	-0.479	0.030
Non-marketable[2]	0.537	-0.005	-0.838*	-0.062
Total	-0.066	0.394	-0.908*	-0.023
Nematodes in soil				
Meloidogyne	0.034	0.426	0.191	0.790*
Criconema	0.700*	0.456	0.397	-0.148
Total per plot	0.229	0.758*	0.352	0.056
Nematodes in roots				
Meloidogyne	0.984*	0.004	0.024	0.051
Pratylenchus	0.985*	-0.032	0.022	0.034
Total per plot	0.984*	0.003	0.025	0.051
Soil chemical characteristics				
EC	0.586	0.604	0.317	0.180
C	0.432	0.786*	0.416	-0.108
P	-0.730*	0.577	0.053	0.362
K	0.143	0.237	0.919*	-0.014
Na	0.573	0.402	0.269	-0.622
Mg	-0.227	0.964*	-0.120	-0.064
H+Al	-0.841*	-0.247	0.286	0.124
SB	0.248	0.883*	-0.330	-0.100
CEC	-0.023	0.951*	-0.293	-0.063
V	0.625	0.663*	-0.337	-0.051
Cu	-0.832*	-0.505	0.182	0.142
Fe	-0.117	-0.386	0.060	0.902*
Mn	0.104	0.540	0.605	0.347
Zn	0.962*	0.223	0.144	0.007
Plant chemical characteristics				
N	0.043	-0.171	0.885*	0.113
P	-0.638	0.222	-0.662*	0.322
K	0.769*	-0.280	0.143	-0.531

*Significant factor loadings; [1]fruits of superior quality and with higher market price; [2]fruits of inferior quality, marketed at prices equivalent to 50% of those of fruits considered marketable.

Table 2. Continuation.

Variables	Factor Loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
	Plant chemical characteristics			
S	0.875*	0.185	0.172	-0.399
B	-0.014	0.726*	0.133	0.635
Mn	-0.249	0.029	-0.560	0.658*
Zn	-0.507	0.329	-0.177	-0.771*
Na	0.433	-0.276	0.052	-0.845*
chlorophyll a	0.645	-0.272	0.462	0.483
Eigenvalue	12.259	7.824	5.779	4.180
Total Variance (%)	38.308	24.450	18.059	13.062
Total Accumulated Variance (%)	38.308	62.757	80.817	93.878

*Significant factor loadings; [1]fruits of superior quality and with higher market price; [2]fruits of inferior quality, marketed at prices equivalent to 50% of those of fruits considered marketable.

Cluster Analysis (CA)

Cluster analysis was used as a confirmatory tool of factor analysis, using only variables with factor loading above 0.65 in factors 1 and 2, because it was observed that the inclusion of significant variables in factor 3 did not alter the formation of clusters. The multivariate analysis allowed the agroecosystems to be grouped based on similar characteristics and the formation of three different clusters regarding the functionalities of the agroecosystems and the variables analyzed (Figure 3).

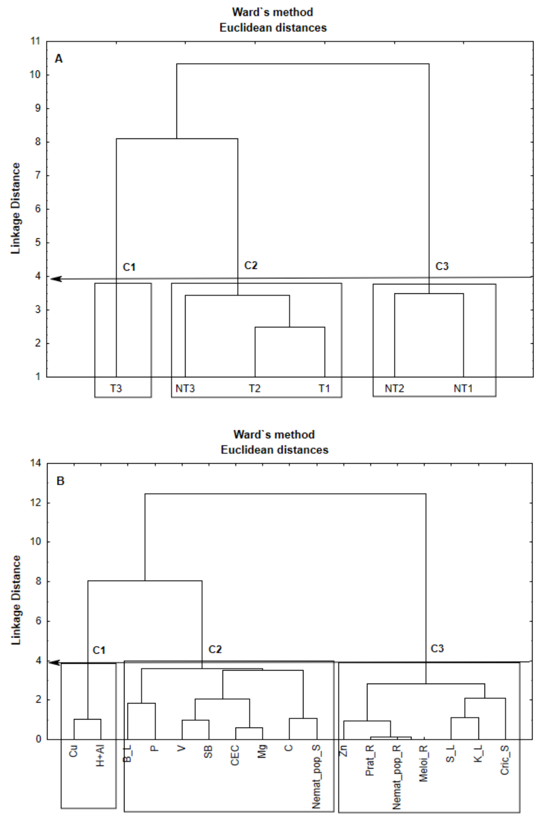

Figure 3. Cluster analysis for yield, nematode population, chemical characteristics of soil samples and leaf contents of nutrients in 'Gladial' yellow melon cultivated in multifunctional agroecosystems in semi-arid environment. (A) clustering by agroecosystems and (B) clustering by variables. C1 - T3: agroecosystem with spontaneous vegetation and soil tillage; C2 - T1: agroecosystem with mixture of cover crops with predominance of legumes (75%) and with soil tillage; T2: agroecosystem with mixture of cover crops with predominance of grasses (75%) and with soil tillage; NT3: agroecosystem with spontaneous vegetation and without soil tillage; C3 - NT1: agroecosystem with mixture of cover crops with predominance of legumes (75%) and without soil tillage; NT2: agroecosystem with mixture of cover crops with predominance of grasses (75%) and without soil tillage.

When the agroecosystems were used as clustering variable (Figure 3A), cluster 1 (C1) was predominantly formed by the agroecosystem that uses spontaneous vegetation as cover crop associated with phytomass incorporation into the soil. This combination showed as function only the reduction of nematode population in the soil and in melon roots. In addition, it had the lowest levels of soil fertility and yield (Figure 3B).

Cluster 2 (C2) was formed by agroecosystems that use the mixtures of commercial cover crops, regardless of composition, with the incorporation of straw, after 70 days of cultivation and before melon planting, in addition to the one in which the straw of spontaneous vegetation is kept on the soil (NT3). This cluster of agroecosystems allows benefits for soil fertility, B contents in leaf tissue and reduction in the population of nematodes in the soil, with good levels of yield. Cluster 3 (C3), formed by the systems that maintain the straw of the mixtures of commercial cover crops on the soil, after the mowing of aerial phytomass, regardless of composition (NT1 and NT2), favors the nutritional status of plants, fertility and the addition of carbon to the soil. Moreover, although this cluster had the highest populations of *Criconema* in the soil, *Meloidogyne*, *Pratylenchus* and total population in the melon roots, there was less variation in production, with yield similar to the average of the region (IBGE, 2021). Thus, agroecosystems that associate the use of plant mixtures with greater diversity of species in their composition and the non-incorporation of plant residues are considered more complex because they perform different environmental functions.

Table 3 shows the values of means and standard deviations for the three clusters formed. It is worth noting that each of the clusters formed by the variables (Figure 3B) corresponds to the clusters formed by the agroecosystems (Figure 3A), with the variables that have, in general, the highest values (Table 3). Although they were not used to obtain the cluster, the means of total and non-marketable (with lower market value) yields were included in Table 3, because they are important as sustainability indicators.

Table 3. Means of the variables that make up the clusters of agroecosystems formed from the cluster analysis.

	C1		C2		C3	
	Mean	SD	Mean	SD	Mean	SD
Nematodes in soil						
Criconema	10.00	24.16	36.67	13.95	67.50	17.08
Total per plot	70.00	73.86	206.67	42.64	212.50	52.23
Nematodes in roots						
Meloidogyne	4237.50	4625.45	5417.50	2670.50	17802.50	3270.69
Pratylenchus	325.00	258.90	341.67	149.48	737.50	183.07
Total per plot	4562.50	4665.81	5759.17	2693.81	18540.00	3299.23
Soil chemical characteristics						
C	30.06	3.36	35.67	1.94	37.13	2.37
P	46.22	6.05	54.99	3.49	44.45	4.28
Mg	0.95	0.16	1.26	0.09	1.11	0.12
H+Al	1.60	0.13	1.49	0.08	1.31	0.10
SB	2.88	0.45	3.87	0.26	3.76	0.32
CEC	4.50	0.42	5.37	0.24	5.09	0.29
V	63.50	3.58	71.12	2.07	73.61	2.53
Cu	1.52	0.08	1.37	0.05	1.24	0.06
Zn	5.43	2.46	6.69	1.42	10.09	1.74
Plant chemical characteristics						
K	35.88	3.49	31.46	2.01	39.56	2.47
S	13.12	1.56	13.48	0.90	15.93	1.10
B	12.45	3.07	18.43	1.77	16.64	2.17
Yields (t ha^{-1})						
Non-marketable[2]	10.83	3.97	12.00	8.35	14.37	4.62
Total	29.58	8.09	35.47	15.50	32.50	7.07
F test	C1 x C2		C1 x C3		C2 x C3	
	2825.51**		18325.40**		17254.87**	

**Significant at 1% probability level by Roy's test; [1]fruits of superior quality and with higher market price; [2]fruits of inferior quality, marketed at prices equivalent to 50% of those of fruits considered marketable.

Spontaneous vegetation has good capacity for accumulating some nutrients, such as Cu, but has lower biomass production and accumulation of bases, which explains the higher potential acidity and the lower C contents in the soil (BAGAGI, 2017; FREITAS et al., 2019).

The smaller populations of nematodes in soil and roots, observed in C1 and C2, may be associated with the use of spontaneous vegetation and/or solarization of the soil due to its turning. Probably, the plants that make up this vegetation, for being adapted to local conditions, are less favorable to phytoparasitic nematodes than commercial cover crops. Thus, better understanding the mechanisms involved in the lower favorability of native plants to the multiplication of nematodes is an important line of research to be investigated. Similarly, using plant mixtures that are less favorable to the most frequent nematodes may also constitute an important management strategy for achieving higher crop yields.

CONCLUSIONS

Multivariate analysis allowed separating the agroecosystems based on similar characteristics into clusters with different functionalities. Incorporation of plant residues into the soil reduces nematode population, but their maintenance on the surface makes it possible to improve fertility, the addition of C to the soil and yield. It is recommended not to incorporate the plant residues, transplanting the melon seedlings directly into the straw, regardless of the mixture of cover crops. Non-incorporation of spontaneous vegetation is also a viable practice and adapted to the semi-arid conditions.

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