Amazonian Journal of Plant Research *©2017 Universidade Federal do Pará*
This paper is available online free of all access charges – Faculdade de Engenharia Agronômica
https://www.ajpr.online - Amaz. Jour. of Plant Resear. 4(1):469-477. 2020

Amazonian Journal of Plant Research

Original Paper

OPEN ACCESS

Effects of different fertilizer and mulching on chemical properties of soil under cabbage cultivation

Eduardo Silva dos Santos[1], Abelardo Antônio de Assunção Montenegro[2] and Plínio Antônio Guerra Filho[1]

1 Federal University of Maranhão, Center of Agricultural and Environmental Sciences, Chapadinha - MA, Brazil

2 Rural Federal University of Pernambuco, Department of Agricutural Engineering, Recife - PE, Brazil

Received: 14 February, 2020. Accepted: 28 March, 2020
First published on the web May, 2020
Doi: 10.26545/ajpr.2020.b00056x

Abstract

Horticulture communal cropping in the semiarid presents a high social and economic relevance, being characterized by water shortage and low soil fertility. The objective of this study was to evaluate the different types of fertilization and use of mulch on soil chemical properties. EC, pH end RAS were measured from the soil cultivated with cabbage in a Fluvisol, and irrigated with micro sprinkler irrigation system, with daily irrigation. Treatments were arranged in a randomized block design in 4 x 2, corresponding to four sources of fertilizer (organomineral, mineral, organic manure - 20 t ha^{-1} of farmyard manure, and without fertilization) and two types ground cover (no mulch presence and mulching in a density of 9 t ha^{-1}), with three replications. The electrical conductivity ranged from 4.31 to 2.37 dS m^{-1}. The alkaline pH always remained independent of the treatments used.

Key-words: Electrical Conductivity, Sodium Adsorption Ratio, *Brassica oleraceae*

Introduction

The process of accumulation of salts in the soil can be either the primary origin, when related to the pedogenetic characteristics of the soil itself, or secondary, when related to anthropic actions. To a worldwide extent, it is estimated that 20% of irrigated land are affected by the salinization caused by the increased volume caused by irrigation (Aragüés et al., 2011). In excess, salts have harmful effects to plant growth, due to the direct effects on osmotic potential and potentially toxic ions present at high concentrations in the soil solution.

There are several irrigated perimeters in Northeast Brazil that present problems of physical and chemical degradation of soils, indicating that, in addition to social and economic issues, the expansion of irrigated agriculture must consider aspects related to the quality of water and soil management (Lopes et al., 2011; Freire et al., 2014; da Silva Filho et al., 2019). Some indexes that evaluate degradation and productivity in agroecosystems have been based on the monitoring of some physical and chemical attributes of the soil (Porto Filho et al., 2011).

Among the chemical attributes, the pH, the cation exchange capacity and exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+} e Na^{+}) and soil organic matter are affected by the practice of irrigation (Assis et al., 2010). Thus, several studies have been conducted, particularly in semiarid regions, with the use of

✉ Eduardo Silva dos Santos
E-mail: santos.eduardo@ufma.br

mulch in the soil as a management practice, contributing to the improvement of the physical and chemical quality of the soil, better crop performance, reduction of soil moisture losses and higher rate of infiltration. (Jordan et al., 2010; Souza et al., 2011; Zonta et al., 2012; Montenegro et al., 2013).

Combined with the use of mulch, we can also highlight the use of organic fertilizer, which in addition to improving soil drainage and aeration, increases water storage capacity, nutrient levels and the population of microorganisms beneficial to the soil and the plant, stimulating root development (Silva et al., 2012).

Therefore, the objective of this work was to evaluate the different types of fertilization and use of mulch on chemical attributes of a Fluvisol such as electrical conductivity (EC), pH, sodium adsorption ratio (SAR), grown with cabbage irrigated perimiter from Brazilian semiarid region.

Materials and Methods

Study area

The study area is located in the municipality of Pesqueira, in the Agreste region of Pernambuco, in the rural settlement named as “Fazenda Nossa Senhora do Rosário”, located in the geographical coordinates 8º 15 'and 8º 30' of South Latitude, 31º 45 'and 37º 00' of West Longitude of Greenwich. The climate is very hot semiarid (Bsh), according to Köppen classification. The average annual precipitation is 607 mm, the average temperature is 23ºC and the potential evapotranspiration is about 2,000 mm per year (Montenegro and Montenegro, 2006).

The soil is characterized as Fluvisol. For the determination of the granulometric fractions before the cultivation of cabbage, in an experimental batch, we used the pipette method, as described by EMBRAPA (1997), whose values are shown in Table 1.

Table 1. Soil physical attributes of the experimental area.

Depth (m)	Clay	Silt	Sand	Texture	Bd	Θ_{cc}	Θ_{pp}
		$g\ kg^{-1}$			$(g\ cm^{-3})$	$cm^3\ cm^{-3}$	
0-0.20	149.68	515.39	334.83	Silty loam	1.52	0.27	0.12
0.20-0.40	169.79	492.10	345.28	Loam	1.49	0.25	0.11

During the study period, from December 22, 2011 to March 13, 2012, air temperature values between 15.7 and 33.8oC and total precipitation of 120.6 mm were recorded. The depths of the local water table level, in the months of December, January, February and March, were 1.61; 2.86; 2.79 and 2.80 m, respectively, and the electrical conductivity of the irrigation water, equal to 1.01, 0.99, 0.94 and 0.91 dS m^{-1}, respectively.

Experimental design

The treatments were arranged in a randomized block design, in a 4 x 2 factorial scheme, corresponding to four levels of fertilization and two levels of soil cover (absence and presence of mulch, with density of 9 t ha^{-1}), with four repetitions. Each block was 18 m long and 15 m wide. The four fertilizations were: organomineral fertilization (Takamix OM); mineral fertilization (Urea, superphosphate and potassium chloride); organic fertilization (20 t ha^{-1} of catle manure) and without fertilization (control).

Each plot had a useful area of 3 x 2 m, which are: T1 - A1CM - Organomineral fertilization with mulch; T2 - A1SCM - Organomineral fertilization without mulch; T3 - A2CM - Mineral fertilizer with mulch; T4 - A2SCM - Mineral fertilization without mulch; T5 - A3CM - Organic fertilization with mulch; T6 - A3SCM - Organic fertilization without mulch; T7 - A4CM - Without fertilization with mulch and T8 - A4SCM - Without fertilization without mulch (control).

Conducting the experiment

The preparation of the experimental area consisted of plowing and mechanized harrowing. A cabbage hybrid called 'Midore' was grown in the 0.5 x 0.4 m spacing. The seedlings were transplanted when they presented 3 to 4 definitive leaves, 21 days after sowing.

Organic, organomineral and mineral fertilization was carried out two days before transplantation. The formulation for fertilization with organomineral and mineral was calculated based on the analysis of soil for the 0-0.2 m layer (Table 2), which corresponded to 159; 222.22 and 66.67 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively and following the needs for the crop, according to the recommendations for the cultivation of cabbage in the State of Pernambuco (CEFS, 2008). Regarding organic fertilization (cattle manure), pits were opened and fertilized with 400 g of manure, corresponding to 20 t ha^{-1} for a planting density of 50,000 plants ha^{-1}.

Table 2. Soil physical attributes of the experimental area.

pH	P	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Al^{3+}	H^{+}	S	CEC	V	OC
	mg dm^{-3}	cmol$_c$ dm^{-3}								%	g kg^{-1}
7.40	120	4.25	2.00	1.07	0.69	0.00	2.93	8.01	10.94	73.22	12.28

CEC – Cation Exchange Capacity; V – Base saturation; S – Sum of bases; and OC – Organic Carbon.

Leaf applications of calcium and boron were performed at 50, 58 and 67 days after transplantation (DAT), with 150 L of solution solution being applied, of which 0.375 L were from the commercial product CAB10, which contains 0.08 L in its composition. of calcium and 0.02 L of boron, as recommended by Filgueira (2008). Periodic weeding was carried out in order to control unwanted spontaneous plants. The mulch was added 15 DAT, using crushed elephant grass, of the "Roxo de Botucatu" variety, covering the entire useful area with the respective treatment.

Irrigation management

The irrigation method used was of the micro-sprinkler type, with a flow rate provided by the manufacturer of 100 L h^{-1} and 100% of the wet area, adopting a daily irrigation shift. The irrigation depths adopted were based on the crop evapotranspiration (ETc), estimated from daily readings in Class A Tank, conducted by the farmer himself, using Tank Coefficient according to local wind conditions, relative humidity and boundary, equal to 0.75, and crop coefficients (Kc) according to Doorenbos and Kassan (1986).

The water used in the irrigation of the experimental area was captured from an Amazon type well, being analyzed the contents of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, pH, electrical conductivity (EC) and determined the Sodium Adsorption Rate (SAR), as shown in Table 3. For the management of irrigation, a leaching fraction of 20% was adopted, which according to Carvalho et al. (2011), was satisfactory for the leaching of salts below the root zone. In calculating the application time of the required blades, the irrigation system test was considered, particularly regarding the application efficiency (Ea = 83%), at a pressure of 150 kPa.

Table 3. Chemical analysis of water used for irrigation in the experimental plot.

Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	EC	pH	SAR
mmol$_c$ L^{-1}				dS m^{-1}		(mmol$_c$ L^{-1})^{0,5}
0.76	0.83	6.33	0.35	1.3	7.5	7.11

Monitoring of soil salinity

The electrical conductivity (EC), pH and the sodium adsorption ratio (SAR), were evaluated below the root region of the culture, being evaluated through the soil solution. For this, porous capsule extractors were installed at a depth of 0.30 m from the soil, using three replicates, that is, a total of 24 monitored plots, of the 32 existing in the experiment. The SAR value was calculated using the following Equation 1:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \qquad (1)$$

where: Na, Ca and Mg represent, respectively, the concentrations of sodium, calcium and magnesium in cmolc L^{-1}.

A voltage of approximately 80 kPa was promoted by means of a manual vacuum pump in the extractors six hours after the end of irrigation. Eighteen hours after applying the vacuum, with the aid of a 250 ml syringe and a silicone rubber attached to it, collections of the soil solution were carried out, in a total of eight campaigns.

The samples were placed in plastic containers with a capacity of 60 mL, and they were transported to the UFRPE Water and Soil Laboratory, where chemical analyzes were carried out. The EC readings were taken by a bench conductivimeter and the pH was determined by a pHmeter. Potassium and sodium were determined by flame photometer; calcium and magnesium by titration with 0.01 M EDTA according to EMBRAPA methodology (1997).

Statistical analysis

The data were analyzed using the SAS computer system (1998) and interpreted based on the significance of the analysis of variance, using the F test, with repeated measures over time. In cases of significant F, the t test was applied at 5% probability.

Results and Discussion

According to the analysis of variance (Table 4), there was a significant effect on time for all variables - electrical conductivity (EC), pH and sodium adsorption ratio (SAR). However, the EC for the interactions between time x fertilization, time x coverage and time x fertilization x coverage did not have a significant effect, even adopting a logarithmic transformation in the data of EC. However, there was no significant effect isolated from fertilization and coverage for any of the variables analyzed. Regarding pH and SAR, significant effects can be verified for the interaction between time x fertilization x cover and interaction between time x fertilization, respectively.

Table 4. Probability for electrical conductivity (EC), pH and sodium adsorption ratio (RAS) over the days after transplanting cabbage seedlings.

Source of variation	DF	EC*		pH		SAR	
		MS	Pr > F	QM	Pr > F	QM	Pr > F
Time	7	0.1087	0.0001^{S}	0.6316	0.0001^{S}	193.0740	0.0001^{S}
Time x F	21	0.0028	0.8334^{NS}	0.0149	0.5366^{NS}	48.9230	0.0004^{S}
Time x C	7	0.0039	0.4507^{NS}	0.0063	0.9018^{NS}	2.1782	0.9965^{NS}
Time x F x C	21	0.0023	0.9273^{NS}	0.0287	0.0271^{S}	11.1736	0.8846^{NS}
Error (time)	98	0.0040		0.0158		17.6521	

DF - Degrees of freedom; MS - Medium square; Pr - Probability at the 5% level; F - Fertilization; C – cover (mulch) * - Data transformed into logarithms; S - Significant; NS - Not significant.

Figure 1 shows the general average data for the EC at a depth of 0.3 m, with their respective standard deviations, throughout the cabbage cultivation cycle. At 21, 28, 36, 41, 48, 56, 64, 77 days after transplant (DAT) the EC was on average 4.31, 3.94, 3.30, 3.06, 3.01, 2, 74, 2.65 and 2.37 dS m^{-1}, respectively. Comparing the EC of the 21st on the last day of monitoring (77 DAT), there was a reduction in the EC values of 54.99%. This reduction can be explained due to the adopted irrigation management, which occurred daily according to the water needs of the crop, with the adoption of a leaching fraction of 20% to provide a layer of leaching of salts from the upper layer of the soil, where the roots of cabbage are found and also because it is a moderately saline irrigation water.

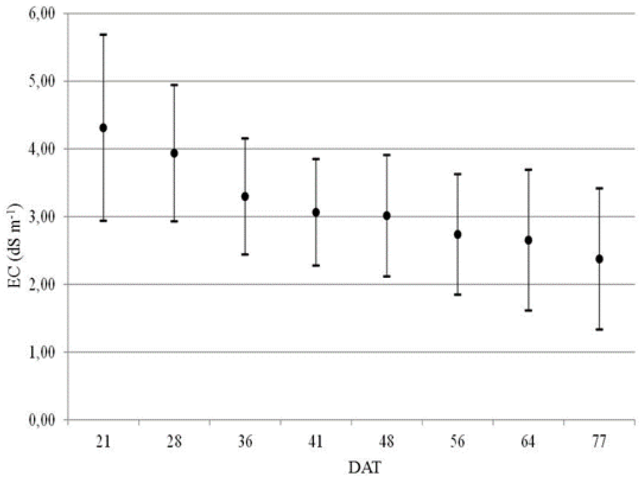

Fig. 1. Average values of electrical conductivity (EC) with their respective standard deviations over the days of cultivation of cabbage at a depth of 0.3 m.

Figure 2 shows the humidity at depths of 0.2 and 0.4 m, assessed with a model 503 DR HYDROPROBE® neutron probe. It is observed that irrigation management was the main factor in the reduction of salinity, since the soil moisture, at a depth of 0.2 m, was always close to the field capacity and above the humidity of the wilt point. permanent. The rainfall in the period during the experiment was 120 mm, which added to the irrigation depths also contributes to the reduction of soil salinity.

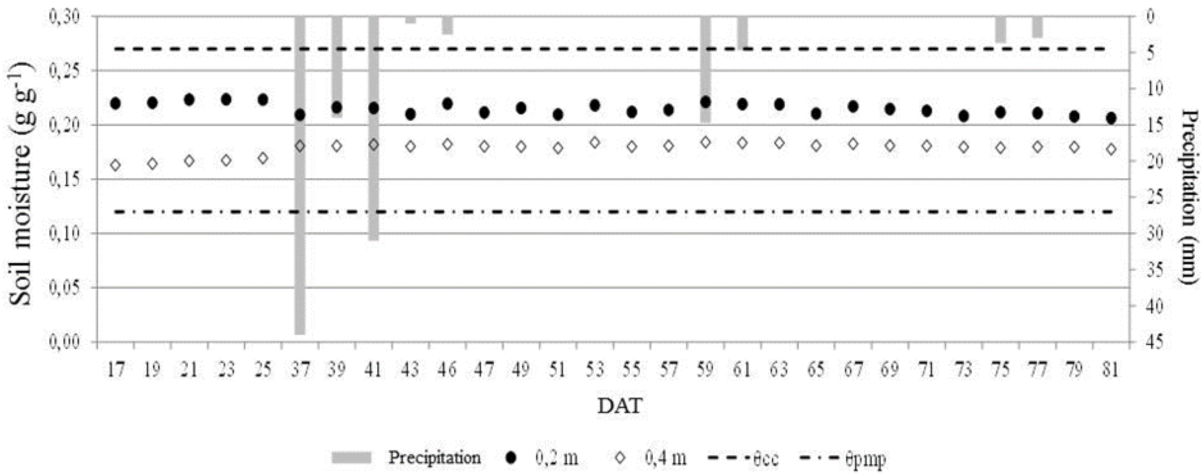

Fig. 2. Temporal distribution of soil moisture at depths of 0.2 and 0.4 m.

Although the mulch was not significant for any of the adopted treatments, it promotes numerous advantages, including improvement in the water supply capacity for crops, providing greater water infiltration in the soil and less evaporation, avoiding precipitation of salts in the root zone; less variation in soil temperature (Montenegro et al., 2013); maintenance of humidity (Souza et al., 2011); this protection makes it possible to increase the amount of water available to the plant.

In the same area as the present study, Souza et al. (2008), evaluating the evolution and spatial variability of salinity under carrot cultivation under irrigation, with moderately saline water and in the presence of mulch of bean stubble with a density of

9 t ha^{-1}, verified in two areas with 900 m^2, that in the 0-40 cm layer, the electrical conductivity of the saturation extract in the area without mulch increased from 2.50 to 3.08 dS m^{-1} and in the area with mulch these authors found reductions in both layers evaluated from 3.51 to 2.91 and 2.90 to 2.53 dS m^{-1} for depths of 0-0.2 and 0.2-0.4 m, respectively.

This importance of mulch was also verified by Lima et al. (2006) when investigating the pepper production, submitted to different irrigation frequencies, mulch (0 and 1000 kg ha^{-1} of corn straw) and irrigation depths with saline water (1.2 dS m^{-1}), in Fluvisol, in a greenhouse, verifying that the adoption of a blade corresponding to 80% of crop evapotranspiration and with mulch, associated with daily irrigation, did not promote a significant increase in soil salinity at the end of the cultivation cycle.

Figure 3 shows the evolution of pH in the presence of mulch (Figure 3A) and in the absence of mulch (Figure 3B), in both cases there was an increase in pH, however from 21 to 77 DAT the pH remained alkaline.

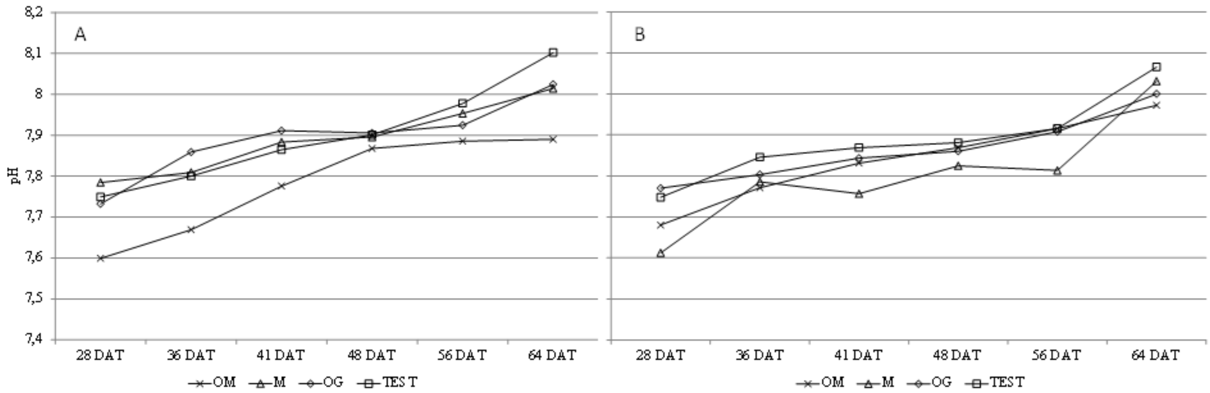

Fig. 3. Moving average of pH for organomineral (OM), mineral (M), organic (OG) and control (TEST) fertilization treatments in the presence of mulch (CM) (A) and in the absence of mulch (SCM) (B).

This increase in pH in cultivated areas may be the result of hydrolysis of fertilizers, such as urea, which is widely used by farmers in the region of the present study (Longo & Melo, 2005). In terms of soil chemical quality, the increase in pH can favor processes of mineralization of soil organic matter, nitrification and biological nitrogen fixation (Mengel et al., 2001). On the other hand, alkaline pH can affect crop development due to reduced availability of micronutrients, such as manganese, copper, zinc and iron (He et al., 2005).

In a Cambisol (Cambissolo Vermelho Amarelo eutrófico típico) under irrigated perennial and annual banana and corn cultivation systems, Dantas et al. (2012) also found an increase in pH in these areas with a variation from 7.2 to 7.8.

Figure 4 shows the average sodium adsorption ratio (SAR) over the cultivation cycle for different fertilization treatments. According to the evolution, it was verified that the organic fertilization from 21 DAT remained always higher in relation to the other fertilizations; and that from 41 to 77 DAT to SAR under the influence of organomineral and mineral fertilizations and without fertilization (control) had a similar behavior. Gonçalves et al. (2011) evaluating chemical changes of a Fluvisol irrigated with saline water, under two values of SAR and six levels of electrical conductivity (EC), found that irrigation water with SAR of 2 and 20 (mmol$_c$ L^{-1})$^{0.5}$ resulted in SAR of the saturation extract of 4.40 and 20.04 (mmol$_c$ L^{-1})$^{0.5}$, respectively.

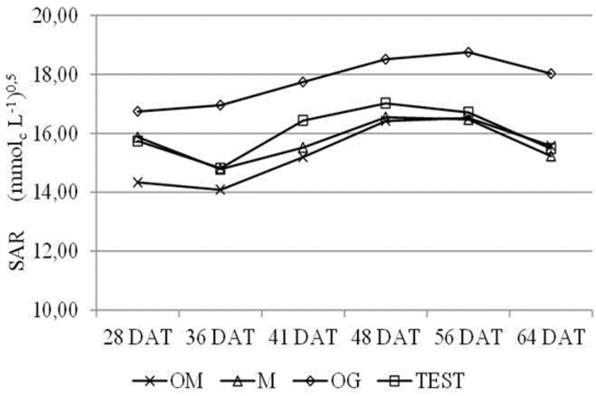

Fig. 4. Average SAR moving for organomineral (OM), mineral (M), organic (OG) and control (TEST) fertilization treatments over the days after transplantation (DAT).

These same authors concluded that there was only an increase in the salinity of the SAR irrigation water equal to 20 $(mmol_c\ L^{-1})^{0.5}$, promoting an increase in the SAR of the soil saturation extract. However, for the type of water used in this experiment that came from an Amazonian well, containing a SAR value of 7.11 $(mmol_c\ L^{-1})^{0.5}$, it appears that the SAR values of the soil solution were above 10 $(mmol_c\ L^{-1})^{0.5}$ and below 20 $(mmol_c\ L^{-1})^{0.5}$ for the entire period analyzed regardless of treatments, which may promote the risk of soil sodification to a evaluated depth of 0.3 m.

Souza et al. (2008), in the same area of the present study, found an increase in SAR from 9 to 11.45 $(mmol_c\ L^{-1})^{0.5}$ after 96 DAT in the 0-20 cm layer and in the 20-40 cm layer this increase was 6.49 to 7.93 $(mmol_c\ L^{-1})^{0.5}$. According to the authors, this increase was attributed to the increase in the sodium content and decrease in the Mg^{2+} content.

Similar results were obtained by Cavalcante et al. (2005), studying soils cultivated with two cotton cultivars under irrigation with saline waters. Silva et al. (2007) also found increasing values of SAR of the soil saturation extract with the increase in salinity and sodicity of irrigation water. Pessoa et al. (2019), in a study with two Fluvisols from the semiarid region of Pernambuco, found an increase in the SAR of the soil saturation extract with the addition of the SAR of the irrigation water.

Conclusion

The mulch and fertilizers did not influence the reduction of the electrical conductivity for the 0.3 m layer studied, being able to be attributed to the adopted management that allowed in the 0.2 m soil layer humidity always close to the field capacity along the time.

Fertilization and mulch did not alter the alkalinity condition of the soil in depth.

The high values of SAR found in this study can promote a risk of soil sodification at a depth of up to 0.30 m.

Conflict of interest: All authors declare no conflict of interest

References

Aragüés, R.; Urdanoz, V.; Çetin, M.; KirdA, C.; Daghari, H.; Ltifi, W.; Lahlou, M.; Douaik, A. 2011. Soil salinity related to physical soil characteristics and irrigation management in four Mediterranean irrigation districts. Agricultural Water Management 98:959-966

Assis, C. P.; Oliveira, T. S.; Dantas, J. N.; Mendonça, E. S. 2010. Organic matter and phosphorus fractions in irrigated agroecosystems in a semi-arid region of Northeastern Brazil. Agriculture, Ecosystems & Environment 138:74-82

Carvalho, J. F.; Montenegro, A. A. A.; Soares, T. M.; Silva, E. F. F.; Montenegro, S. M. G. L. 2011. Produtividade do repolho utilizando cobertura morta e diferentes intervalos de irrigação com água moderadamente salina. Revista Brasileira de Engenharia Agrícola e Ambiental 15:256-263

Cavalcante, I. H. L.; Oliveira, F. A.; Cavalcante, L. F.; Beckmann, M. Z.; Campos, M. C. C.; Gondim, S. C. 2005. Crescimento e produção de duas cultivares de algodão irrigadas com águas salinizadas. Revista Brasileira de Engenharia Agrícola e Ambiental 09:108-111

CEFS – Comissão Estadual de Fertilidade do Solo. Recomendações de adubação para o Estado de Pernambuco. (2ª aproximação) 3.ed. revisada. Recife: Instituto Agronômico de Pernambuco - IPA, 2008. 212p

Dantas, A. N.; Oliveira, T. S.; Mendonça, E. S.; Assis, C. P. 2012. Qualidade de solo sob diferentes usos e manejos no Perímetro Irrigado Jaguaribe/Apodi, CE. Revista Brasileira de Engenharia Agrícola e Ambiental 16:18-26

Da Silva Filho, R. V.; De Almeida, R. H.; Do Nascimento, A. H. C. 2019. Combined effects of salinity and *Trichoderma harzianum* on growth of cucumber (*Cucumis sativus* L.). Amazonian Journal of Plant Research 3:327-335

Doorenbos, J., Kassam, A. H. 1997. Yield response to water. Rome: FAO, Irrigation and Drainage Paper, 33. 1986. EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária. Manual de métodos de análise de solo. Rio de Janeiro: EMBRAPA. 212p.

Filgueira, F. A. R. 2008. Novo Manual de Olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa: UFV, 402p

Freire, M.B.G.S.; Miranda, M.F.A.; Oliveira, E.E.M.; Silva, L.E.; Pessoa, L.G.M.; Almeida, B.G. 2014. Agrupamento de solos quanto à salinidade no Perímetro Irrigado de Custódia em função do tempo**.** Revista Brasileira de Engenharia Agrícola e Ambiental 18:86-91

Gonçalves, I. V. C.; Freire, M. B. G. S.; Santos, M. A.; Santos, E. R.; Freire, F. J. 2011. Alterações químicas de um Neossolo Flúvico irrigado com águas salinas. Revista Ciência Agronômica 42:589-596

He, Z. L.; Yang, X. E.; Stoffella, P. J. 2005. Trace elements in agroecosystems and impacts on the environment. Journal of Trace Elements in Medicine and Biology 19:125-140

Jordán, A., Zavala, L. M., Gil, J. 2010. Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Catena 81:77–85

Lima, P. A.; Montenegro, A. A. A.; Junio, M. A. L.; Santos, F. X.; Pedrosa, E. M. R. 2006. Efeito do manejo da irrigação com água moderadamente salina na produção de pimentão. Revista Brasileira de Ciências Agrárias 1:73-80

Longo, R. M.; Melo, W. J. 2005. Hidrólise da uréia em latossolos: Efeito da concentração de uréia, temperatura, pH, armazenamento e tempo de incubação. Revista Brasileira de Ciência do Solo 29:651-657

Lopes, F.B.; ChaveS, L.C.G.; Andrade, E.M.; Crisostmo, L.A. 2011. Risco de degradação em solo irrigado do perímetro irrigado baixo Acaraú, Ceará. Irriga 16:424-435

Mengel, K.; Kirkby, E.A.; Kosegarten, H.; Appel, T. 2001. Principles of plant nutrition. 5.ed. Dordrecht: Kluwer Academic Publishers, 849p

Montenegro, A. A. A.; Abrantes, J. R. C. B.; DE Lima, J. L. M. P.; Singh, V. P.; Santos, T. E. M. 2013. Inpact of mulching on soil and water dynamics under intermittents simulated rainfall. Catena109:139-149

Montenegro, A. A. A.; Montenegro, S. M. G. L. 2006.Variabilidade espacial de classes de textura, salinidade e condutividade hidráulica de solos em planície aluvial. Revista Brasileira de Engenharia Agrícola e Ambiental 10:30-37

Pessoa, L. G. M.; Freire, M. B. G. S.; Santos, R. L.; Freire, F. J.; Miranda, M. F. A.; Santos, P. R. 2019. Saline water irrigation in semiarid region I – effects on soil chemical properties. Australian Journal of Crop Science 13:1169-1176

SAS. The SAS System for windows: Release version: 6.8, 3.ed. Cary, 1998. CD-Rom

Silva, M. O.; Freire, M. B. G. S; Mendes, A. M. S.; Freire, F. J.; Duda, G. P.; Souza. C. E. S. 2007. Risco de salinização em quatro solos do Rio Grande do Norte sob irrigação com águas salinas. Revista Brasileira de Ciências Agrárias 02:08-14

Silva, J.A.; Oliveira, A.P.; Alves, G.S.; Cavalcante, L.F.; Oliveira, A.N.P.; Araújo, M.A.M. 2012. Rendimento do inhame adubado com esterco bovino e biofertilizante no solo e na folha. Revista Brasileira de Engenharia Agrícola e Ambiental16:253-257

Souza, E. R.; Montenegro, A. A. A.; Freitas, M. B. G. S. 2008. Evolução e variabilidade espacial da salinidade em Neossolo Flúvico cultivado com cenoura sob irrigação. Revista Brasileira de Engenharia Agrícola e Ambiental 12:584-592

Souza; E. R; Montenegro, A. A. A.; MontenegrO, S. M. G.; Matos, J. A. 2011. Temporal stability of soil moisture in irrigated carrot crops in Northeast Brazil. Agricultural Water Management 99:.26-32

Porto Filho, F.Q.; Medeiros, J.F.; Gheyi, H.R., Dias, N.S.; Sousa, P.S.; Dantas, D.C. 2011. Evolução da salinidade e pH de solo sob cultivo de melão irrigado com água salina. Revista Brasileira de Engenharia Agrícola e Ambiental 15:1130-1137

Zonta, J. H., Martinez, M. A., Pruski, F. F., Silva, D. D., Santos, M. R. 2012. Effect of successive rainfall with different patterns on soil water infiltration rate. Brazilian Journal of Soil Science 36:377-388

Cite this article as:

dos Santos, E.S.; Montenegro, A.A.A.; Filho, P.A.G. 2020. Effects of different fertilizer and mulching on chemical properties of soil under cabbage cultivation. **Amaz. Jour. of Plant Resear.** 4(1): 469-477.

Submit your manuscript at
https:// www.ajpr.online