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Solarized manure and two irrigation methods on fruit yield of jalapeno chili (*Capsicum annuum* L. var. annuum)

Estiércol solarizado y dos métodos de riego en la producción de chile jalapeño (*Capsicum annuum* L. var. annuum)

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Abstract

Increase of water use efficiency in crops through better irrigation systems and use of farmyard manure to fertilize plants and avoid contamination are needs in arid regions. The objective was to evaluate a jalapeño pepper crop with organic fertilization and two irrigation methods.This research was carried out at Gomez Palacio, Durango, Mexico, in 2013 and 2014. The experimental units were randomly distributed in a split plot design with four replications. Main plots were irrigation treatments and fertilizers were applied as split plot treatments within each irrigation treatment. Irrigation was applied with either a furrow irrigation system to apply 80% of the measured pan evaporation or drip irrigation set to deliver 60% of the measured evaporation. The drip irrigation treatment showed greater fruit yield than the surface irrigation ($p<0.05$). Green fruit yield was similar among fertilized treatments in 2013 ($p>0.05$) and different in 2014 ($p<0.05$) with 40 t ha^{-1} solarized manure having the greatest fruit yield. Soil organic matter and nitrate-N content were greatest in 2013 when solarized manure 40 t ha^{-1} was used. There were no differences among fertilizer treatments in 2014 ($p>0.05$). Soil pH and electrical conductivity remained unchanged among treatments in each year of the study. Drip irrigation had a positive effect in the fruit yield in spite of delivering a lesser amount of water. The solarized manure applied at 40 t ha^{-1} had the greater effect in the fruit yield in year 2 but not in year 1.

Keywords
fruit yield • fertilizers • nitrates • organic matter • evaporation

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Resumen

Incrementar el uso eficiente del agua a través de mejores sistemas de irrigación y el uso de estiércol de vaca para fertilizar plantas y evitar la contaminación son necesidades en regiones áridas. El objetivo fue evaluar un cultivo de chile jalapeño con fertilización orgánica y dos métodos de irrigación. La investigación fue llevada a cabo en Gómez Palacio, Durango, México en 2013 y 2014. Las unidades experimentales fueron distribuidas aleatoriamente en un diseño de parcelas divididas con cuatro repeticiones. Las parcelas grandes fueron los tratamientos de irrigación y los tratamientos de fertilización fueron las subparcelas. El agua aplicada a través de surcos de irrigación fue el 80% de evaporación medida en un tanque evaporímetro o bien a través del riego por goteo para aplicar 60% del agua evaporada. El tratamiento de riego por goteo mostró mayor cosecha de fruto que el riego por surcos ($p<0,05$). La cosecha de fruto fue igual entre los tratamientos de fertilización en 2013 ($p>0,05$) y diferente en 2014 ($p<0,05$) con el tratamiento de 40 t ha^{-1} de estiércol solarizado teniendo la mayor producción de fruto. La materia orgánica del suelo y el contenido de nitratos fueron mayores en 2013 en el tratamiento 40 t ha^{-1} de estiércol solarizado. No hubo diferencias entre tratamientos de fertilización en 2014. El pH del suelo y la conductividad eléctrica no tuvieron cambios entre tratamientos en los dos años de estudio. El riego por goteo tuvo un efecto positivo en la producción de fruto a pesar de que se aplicó menos cantidad de agua. El estiércol solarizado aplicado a 40 t ha^{-1} tuvo el mayor efecto en el año 2 pero no en el año 1.

Palabras clave

producción de fruto • fertilizantes • nitratos • materia orgánica • evaporación

Introduction

In Mexico there are approximately 500,000 ha in irrigation districts, mainly in arid and semiarid areas where water problems are exacerbated by the extraction rates exceeding infiltration rates which it leads to salinization; in regions such as the Laguna region, which is located to the northeast part of the State of Durango and in the southwestern State of Coahuila (22). This region extracts an average of 930.92 million m^3 per year but only 518.9 million m^3 are recharged. Therefore the ground water table loses almost two meters per year (9). Surface irrigation accounts for 94% of the irrigated land area in Mexico. In the La Laguna region low efficiency in irrigation systems account for 63% of the water losses which includes water loss from storage dams to crop areas (9). There is, therefore, the need to increase irrigation efficiency by changing to pressurized systems. Water use efficiency can also be further increased by improving fertilization techniques which should provide more biomass per m^3 of water. Implementation of suitable irrigation methods that apply lower amounts of water, especially during the germination stage when it is difficult to keep the seedbed sufficiently moist, would improve crop yield. Economic crops such as jalapeno pepper would benefit the region with improved water use efficiency (4, 28).

Another problem in the Laguna Region is an unmanaged use of dairy manure.

The region is home of a burgeoning dairy industry of over 400,000 head that contributes over 900,000 t of dry matter per year (14). The manure is not properly utilized for crop production but with proper management it could provide organic nutrients for plants as it decomposes in the soil. The current practices include direct application of manure to agricultural soils without any regard to an optimum rate of application.

Manure appears to be over-applied but with no available studies in the region to determine an optimum rate for a given crop it is not known what side effects may be occurring (15). Manure could also be composted or vermi-composted if it were known what effects it would have on crop growth.

The use of manure or compost is becoming increasingly important and efficient means of recycling of nutrients, which helps crop growth and returns many of the elements extracted during the milk production process to the ground (31).

Peppers are an important commodity around the world and Mexico is the second largest producer in the world with an area of 143,465 ha, producing 2.73 million t (13). The jalapeno pepper (*Capsicum annuum* L. var. annuum) is one of the most important economic chiles within those grown in Mexico for its wide consumption, high profitability and a high labor demand (31). In response to these problems this research was conducted in jalapeno pepper where the objectives were to find optimum amounts of solarized cow-manure for jalapeno, and determine if drip irrigation could improve water use efficiency over that of furrow irrigation.

Materials and methods

This study was carried out in 2013 and 2014, in the experimental agricultural field (CAE) of the Facultad de Agricultura y Zootecnia (FAZ) de la Universidad Juárez del Estado de Durango (UJED), located at km 30 of the Gomez Palacio-Tlahualilo road in ejido Venecia, municipality of Gomez Palacio, Durango, Mexico (25°46'56" N and 103°21'02" W, 1110 m a. s. l.).

The climate, according to the classification of Köppen, modified by García (2004), is steppe (BS) and desert (BW), an arid climate with an average annual rainfall of 230 mm, a yearly evaporation of 1380-2530 mm, and an average annual temperature of 20.7°C. Rainfall during the study was 79.9 mm in 2013 and 153.4 mm in 2014, maximum average temperature was 33.4°C and 33.5°C, and minimum average temperature 20.0°C and 20.5°C in 2013 and 2014.

Solarization of manure

Manure was solarized by making a mound 1.0 m high and 2.0 m wide and 3.0 m long, after that it was covered with a polyethylene plastic without albedo which was held tight by applying soil around the edges of the plastic. Water was applied at the beginning of solarization to reach a moisture content of 55% in order to have better heat distribution through the manure. Solarized manure was analyzed using the Kjeldahl method for total N (21) finding 1.42%, at the time of incorporation into the soil in the laboratory of the National Center of Disciplinary Research in Water-Relationship Floor-Plant-Atmosphere (CENID-RASPA) of Gomez Palacio Durango, Mexico.

Treatments

The treatments resulted from the combination of two factors under a split-plot design randomly distributed. The whole plot was the irrigation methods with 4 repetitions (drip and furrow irrigation); the split-plot fertilization treatments of 20 and 40 t ha^{-1} of solarized manure, a chemical treatment of 160-80-00 (NPK kg) and zero fertilization with 8 repetitions. All plots were first prepared by plowing to a depth of 30 cm followed by harrowing and land leveling. Experimental units (EU) were 3.2 m wide x 3 m long, with 8 EU having each fertilized treatment including the control treatment. The research was carried out at the same place, with the same treatments administered to the experimental units.

Dairy manure was exposed to solar radiation for two months before it was applied to the soil. Manure was incorporated into the soil in the first year by using a scraper to get a uniform area on the ground before plowing. In the second year manure was incorporated by harrowing. Synthetic fertilizer (80-80-00) was applied individually at transplanting as 153.8 kg ha^{-1} of monoammonium phosphate (11-52-00) and 137.13 kg ha^{-1} of urea (46-00-00).

The remainder nitrogen (80-00-00) was applied at 50 days after transplanting as 173.91 kg ha^{-1} of urea. Drip irrigated plots were watered every four days corresponding to 60% of the amount of pan evaporation that had occurred for a total of 60 cm in 2013 and 51 cm in 2014. The irrigation system consisted of PVC pipe (0.019 m ID) where there were connected 20 cm length polyethylene hoses (0.013 m ID) each 0.8 m.

The other side of each polyethylene hose was connected to a drip tape (0.016 m ID, wall thickness 0.152 mm) with emitters spaced every 0.15m with a hydraulic output (Q) of 0.65 L/h at 1.0 bar pressure.

Furrow irrigation was every 15 days. A total of 78 cm of water was applied in 2013 according to 80% of pan evaporation (Type A tank EV). There was 63 cm applied in 2014. Jalapeno seedlings var. 'Compadre' were transplanted on April 23, 2013, and May 05, 2014, transplants had 10 true leaves and a height of 20 cm, including the roots. Transplants were first seeded 50 days before transplanting. Distance between plants was 0.4 m and between rows 0.8 m, which gives a density of 31250 plants ha^{-1}.

The amount of nitrogen in manure treatments was based on analysis of the cattle manure, 1.42%, and considering that 30% of the N in the manure would be mineralized in the first year (11, 12).

Before planting in 2013, 10 random soil samples were taken from the entire treatment location. Soils were sampled again at the end of the last harvest in each year by taking one sample in each experimental unit. One kg of soil was collected from each of two depths (0-30cm depth and 30-60cm). Soil parameters that were measured in the experimental site were organic matter, soil texture, nitrate-N, pH and electrical conductivity. Amount of organic matter was estimated with the Walkley-Black method and soil texture with the Bouyucos method (26). The nitrate concentration was estimated with a transnitration of salicylic acid (23), electrical conductivity and pH by using an electrical spectrophotometer (Genesys 10S UV-Vis) (23).

Before planting, soil organic matter values were 2.41 and 1.46%, nitrates 3.80 and 1.12 mg kg^{-1}, electrical conductivity 3.13 and 3.55 dS m^{-1}, pH 7.8 and 7.06 at the soil depth of 0-30 cm and 30-60 cm respectively. Soil texture was silty clay loam at both soil depths.

To measure green fruit yield, five plants were randomly chosen at the beginning of the first harvest in each experimental unit, and the next measurements were carried out in the same plants the following harvests. Green fruit yield per ha was estimated considering 31,250 plants in this area. Fruit length and fruit width was measured randomly in 25 plants in each experimental unit and the average was analyzed. In 2013, plots were harvested June 20, July 5, July 20, August 5, August 20, and September 5. In 2014, plots were harvested July 4, July 25, August 15, August 28, and September 10.

Results

Green fruit yields

There was no difference among split plots fertilization treatments on total fruit yield in 2013 ($p>0.05$), and the highest fruit yield was found in the 40 t ha^{-1} manured treatment in 2014 ($p<0.05$) (table 1).

Total fruit yields of the whole plots treatments showed difference in 2013 and 2014 ($p<0.05$), the drip irrigation treatment was significantly higher than the furrow irrigation treatment. Respect to the fruit yield per harvest, the split plot fertilized treatments showed no differences ($p>0.05$) in 2013 (table 2, page 110).

In the first harvest of 2014, the 40 t ha^{-1} manured treatment was higher than the 20 t ha^{-1} manured treatment and similar to the other treatments ($p<0.05$). In the second harvest, the 40 t ha^{-1} manured treatment was higher than the control and the 20 t ha^{-1} manured treatment and similar to the chemical treatment ($p<0.05$). In the third and fourth harvests there were no differences among fertilized treatments ($p>0.05$).

Table 1. Green fruit yield, fruit length, and fruit width of *Capsicum annuum* L. of the periods evaluated at Facultad de Agricultura y Zootecnia, UJED, Gómez Palacio, Dgo. Mexico.

Tabla 1. Producción de fruto verde, longitud y ancho del fruto de *Capsicum annuum* L. en los períodos evaluados en la Facultad de Agricultura y Zootecnia, UJED, Gómez Palacio, Dgo. Mexico.

	---green fruit yield--- (t ha^{-1})		----fruit length---- (cm)		---fruit width--- (cm)	
	2013	2014	2013	2014	2013	2014
------sub-plot fertilized treatments------						
M40[1]	50.98 a[3]	44.95 a	6.30 a	4.64 b	2.17 a	2.66 a
M20	50.53 a	34.60 b	6.06 b	4.82 a	2.13 ab	2.53 a
ChT	52.03 a	37.91 ab	6.26 a	5.08 a	2.12 ab	2.65 a
CT	47.02 a	35.05 b	6.21 a	5.10 a	2.07 b	2.53 a
------Whole plots, irrigation treatments------						
DI[2]	56.61 a	41.41 a	6.42 a	5.04 a	2.18 a	2.63 a
FI	43.67 b	34.84 b	5.99 b	4.76 a	2.06 a	2.55 a

[1] M40 = 40 t ha^{-1} of solarized manure, M20 = 20 t ha^{-1} of solarized manure, ChT = 160-80-00 of NPK kg, CT = without any fertilized treatment. [2] DI = drip irrigation. FI = furrow irrigation. [3] Means with different letter in the same column show significant differences ($p<0.05$).

[1] M40 = 40 t ha^{-1} de estiércol solarizado, M20=20 t ha^{-1} de estiércol solarizado, ChT = tratamiento químico 160-80-00 de NPK kg, CT = sin tratamiento de fertilización. [2] DI = riego por goteo, FI = riego por surcos. [3] Medias con letra diferente en la misma columna muestran diferencia significativa ($p<0,05$).

Table 2. Green fruit yield per harvests of *Capsicum annuum* L. in the subplot and the whole plot treatments.

Tabla 2. Producción de fruto verde por cosecha de *Capsicum annuum* L. en los tratamientos de las subparcelas y parcelas grandes.

	Ȳ1[1]		Ȳ2		Ȳ3		Ȳ4		Ȳ5		Ȳ6	
Subplots[2]	------------------------- Green fruit yield (t ha^{-1}) 2013 -------------------------											
M40	5.27	a[3]	9.87	a	7.68	a	9.71	a	9.73	a	9.06	a
M20	5.26	a	11.34	a	6.24	a	9.31	a	8.40	a	11.22	a
ChT	4.71	a	10.08	a	8.30	a	9.52	a	9.60	a	10.34	a
CT	4.09	a	10.92	a	6.24	a	9.75	a	8.43	a	8.94	a
Subplots	--------------------------- Green fruit yield (t ha^{-1}) 2014 ---------------------------											
M40	9.17	a	9.42	a	6.48	a	9.41	a	9.60	a		
M20	6.24	b	7.12	b	5.58	a	7.37	a	7.17	b		
ChT	7.21	ab	7.69	ab	6.99	a	7.70	a	8.04	ab		
CT	7.27	ab	7.13	b	6.75	a	7.02	a	7.40	b		
Whole plots[4]	------------------------- Green fruit yield (t ha^{-1}) 2013 -------------------------											
DI	6.37	a	12.13	a	9.04	a	10.03	a	10.54	a	9.91	a
FI	3.29	b	8.96	a	5.97	b	9.14	a	7.82	a	9.96	a
	----------------------- Green fruit yield (t ha^{-1}) 2014 -----------------------											
DI	8.12	a	8.37	a	6.74	a	8.60	a	8.81	a		
FI	7.04	a	7.29	a	6.18	a	7.10	b	7.35	b		

[1] Mean of the harvest number one. [2] M40 = 40 t ha^{-1} of solarized manure, M20 = 20 t ha^{-1} of solarized manure, ChT = Chemical treatment 160-80-00 of NPK kg, CT = without any fertilized treatment. [3] Means with different letter in the same year and column show significant differences ($p<0.05$). [4] D I = drip irrigation, FI = furrow irrigation.

[1] Media de la cosecha número uno. [2] M40=40 t ha^{-1} de estiércol solarizado, M20 = 20 t ha^{-1} de estiércol solarizado, ChT = tratamiento químico 160-80-00 de NPK kg, CT = sin tratamiento de fertilización. [3] Medias con letra diferente en el mismo año y columna muestran diferencia significativa ($p<0,05$). [4] DI = riego por goteo, FI = riego por surcos.

In the whole plot treatments, fruit yield was greater in drip irrigation treatment than furrow irrigation only in the first and third harvests in 2013, and in the fourth and fifth harvests in 2014 ($p<0.05$).

In the other harvests no differences were found ($p>0.05$) (table 2).

Fruit length and fruit width

In the whole-plot treatments, the greatest fruit length was found in drip irrigation treatment in 2013 ($p<0.05$) and there was no difference between treatments in 2014 ($p>0.05$) (table 1, page 109). The 20 t ha^{-1} manured treatment showed the lowest fruit length in the split plot treatments ($p<0.05$) in 2013. In 2014, the 40 t ha^{-1} manured treatment showed lower fruit length than the other fertilized treatments ($p<0.05$) (table 1, page 109).

In fruit diameter, the 40 t ha^{-1} manured treatment showed no differences with the other treatments in 2013, and having greater fruit diameter than the control treatment ($p<0.05$) (table 1, page 109). The chemical, the 20 t ha^{-1} manured and control treatments showed similar diameter fruit ($p>0.05$). There was no difference in this variable among split plot fertilized treatments in 2014 ($p>0.05$). In the whole plots there was no difference between treatments in 2013 and 2014 ($p>0.05$).

Soil organic matter

In 2103, in the split plot fertilized treatments, the 20 and 40 t ha^{-1} manured treatments had similar amount of soil organic matter found at a soil depth of 0-30 cm ($p>0.05$). The 20 t ha^{-1} manured treatment showed greater amount of soil organic matter than the other treatments in this soil depth ($p<0.05$) (figure 1, page 112). At the same soil depth, the 40 t ha^{-1} manured treatment was similar to the control treatment and greater than the chemical treatment in this variable ($p<0.05$). The control and chemical treatments had similar amount of soil organic matter at that same soil depth ($p>0.05$). In 2014, no differences were found among split plot fertilized treatments at the soil depth before mentioned ($p>0.05$).

In the whole plots there was no significant difference of organic matter in 2013 and 2014 at this soil depth of 0-30 cm ($p>0.05$). There were no significant differences of soil organic matter at a depth of 30-60 cm for neither the split plot fertilizer treatments nor the whole plot irrigation treatments ($p>0.05$) (figure 1, page 112).

Nitrates, pH and electrical conductivity (EC)

The 40 t ha^{-1} manured treatment had the greater amount of nitrates than the other treatments ($p<0.05$) at the 0-30 cm soil depth level in 2013. In 2014 there were no differences among split plot fertilization treatments ($p>0.05$). In the whole plots, drip and furrow irrigation, there was no difference at this soil depth in both years ($p>0.05$) (figure 1, page 112).

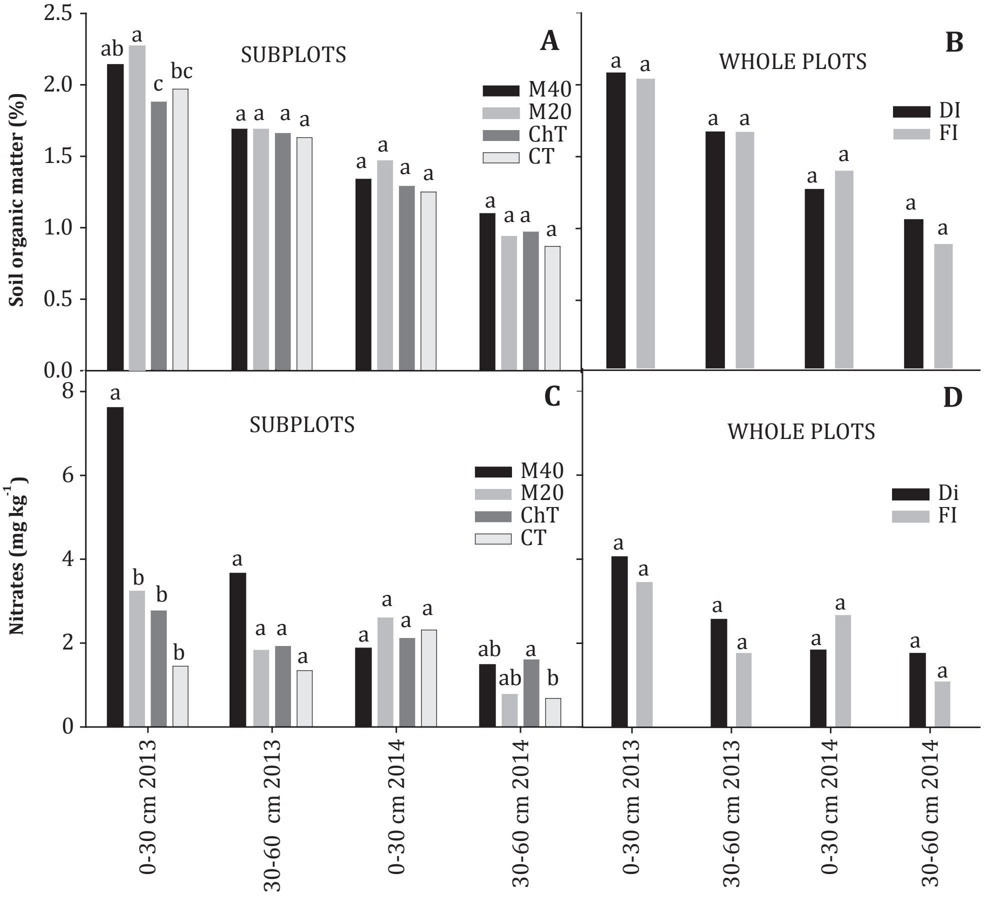
In the split plot fertilized treatments, the chemical treatment was similar to the manured treatments and greater than the control treatment ($p<0.05$) in nitrates concentration at soil depth of 30-60 cm, and control treatment showed no differences with the manured treatments ($p>0.05$). In the whole plot treatments there was no difference in nitrates at this soil depth (figure 1, page 112). Significant difference was not found neither for split plot fertilized or whole plot irrigation treatments in pH and EC at 0-30 cm soil depth level ($p>0.05$) (figure 2, page 113).

Discussion

Green fruit yield

Assouline *et al.* (2006), in order to investigate irrigation frequencies (up to 10 per day), found that the highest values of yield (5 kg m^{-2}), efficiency of water use (10.7 kg m^{-3}) was achieved with a daily irrigation drip, because the frequencies generated higher irrigation crop damage by excessive accumulation of salts in the rhizosphere. In the same species, Sezen *et al.* (2006) found that the highest yield of fresh fruit (33.1 t ha^{-1}) was obtained when irrigation was applied to achieve a consumption of 18-22 mm of evaporation of a standard tank type "A", with a coefficient of development crop equals one.

These green fruit yields are similar to those found by Vázquez-Vázquez *et al.* (2011) and higher than those reported by Ashrafuzzaman *et al.* (2011). These results were in a certain way because of the jalapeño hybrid 'Compadre' is one of the chili crops that are cultivated in the Center-North region of Mexico which have higher fruit yields than those hybrids that are cultivated in the Mexico South-Gulf region (2). When the amount of fertilizer that the plant needs is applied to the soil instead of recommended applications in a certain region, yield results are better without N losses (10).

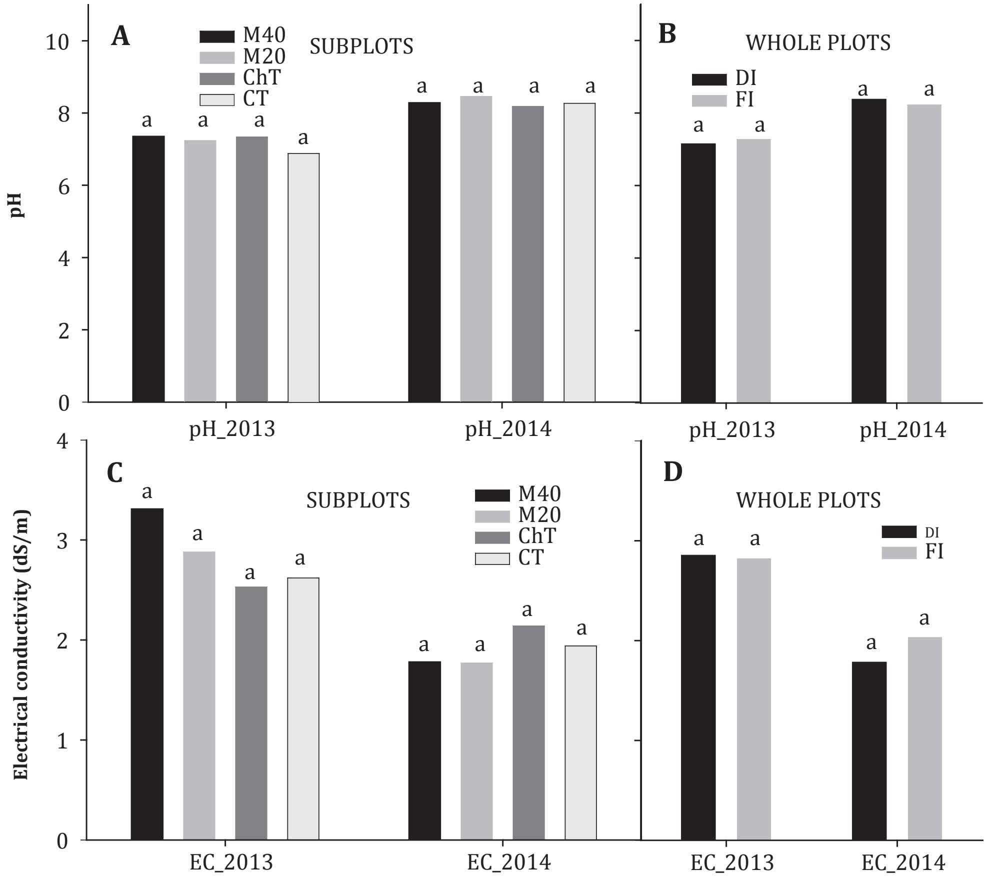


M40 = 40 t ha^{-1} of solarized manure. M20 = 20 t ha^{-1} of solarized manure. ChT = chemical treatment 160-80-00 kg of NPK. CT = without any fertilized treatment. DI = drip irrigation. FI = furrow irrigation. Means with different letter in the same column (date) show significant differences ($p<0.05$).

M40 = 40 t ha^{-1} de estiércol solarizado. M20 = 20 t ha^{-1} de estiércol solarizado. ChT = tratamiento químico 160-80-00 kg de NPK. CT = sin fertilizante. DI = riego por goteo. FI = riego por surcos. Medias con letra diferente en la misma columna (fecha) muestran diferencia significativa ($p<0,05$).

Figure 1. Soil organic matter (A and B) and nitrates (C and D) found after jalapeño pepper was harvested.

Figura 1. Materia orgánica del suelo (A y B) y nitratos (C y D) encontrados después de que el chile jalapeño fue cosechado.



M40 = 40 t ha^{-1} of solarized manure. M20 = 20 t ha^{-1} of solarized manure. ChT = chemical treatment 160-80-00 of NPK kg. CT = without any fertilized treatment. DI = drip irrigation. FI = furrow irrigation. Means with similar letter in the same column and year show no significant differences (p>0.05).

M40 = 40 t ha^{-1} de estiércol solarizado. M20 = 20 t ha^{-1} de estiércol solarizado. ChT = tratamiento químico 160-80-00 de NPK kg. CT = sin fertilizante. DI = riego por goteo. FI = riego por surcos. Medias con letras iguales en la misma columna y año no muestran diferencias significativas (p>0,05).

Figure 2. pH (A and B) and electrical conductivity (EC, C and D) at the depth soil of 0-30 cm after the jalapeño pepper was harvested in 2013 and 2014.

Figura 2. pH (A y B) y conductividad eléctrica (EC, C y D) del suelo a 0-30 cm de profundidad después de que el chile jalapeño fue cosechado en 2013 y 2014.

In this way, the highest fruit yield found in 2014 is according to the results found by Vázquez-Vázquez *et al.* (2011) who found the best yield with the application of 40 t ha^{-1} of manure. It seems that in the first year (2013) manure and chemical fertilizers had no effects on green fruit yields, but in the second year (2014) of the manure and chemical fertilizer application an accumulative effect was showed in the fruit yield.

Fruit length and fruit width

Sermenli and Mavi (2010) reported similar fruit length results. Ashrafuzzaman *et al.* (2011) and Gunawardena and De Silva (2014) showed lower length fruit than this research and Jayasree and George (2006) found greater length fruit of jalapeño pepper. Also, Sermenli and Mavi (2010) found similar results in fruit width. Ashrafuzzaman *et al.* (2011) and Gunawardena and De Silva (2014) showed lower fruit width in research they carried out.

Organic matter

Soil organic matter is an important factor for providing nutrients supply (19), especially nitrogen (17), but it is known that the nutrients of the organic matter are not available for plants at the beginning (30). In the first year of manure application, the results in fruit yield were similar to the control treatment and there was more residual soil organic matter in the manured treatments.

In the second year of manure application, equal percentages of residual organic matter in the soil were found among the treatments and the 40 t ha^{-1} manured treatment had the greatest fruit yield what it indicates that organic matter was more useable by plants trough net N mineralization process in the soil (12), and repeated applications of farmyard manure increase the N availability for plants (8).

Nitrates

The nitrates had a similar tendency that soil organic matter. There were more soil nitrates in the first year in the manured treatments after the fruit yield was done, but this fruit yield did not show a difference with the control treatment, what it could indicate that nitrates were no available to be used by plants at that time (30), but in the second year the soil nitrates were lower at the end of the last harvest than the first year in the manured treatments, what it could indicate that nitrates were used by plants to get more fruit production.

In the second year, the results show that fruit yield was greater in the 40 t ha^{-1} manured treatment and the depletion of nitrates found in the soil indicates that N was used by plants instead of being lost by denitrification.

The reason why people adds manure is due to its low C:N ratio where microorganisms do not have any trouble to mineralize N and plant available-N increases in soil (7, 24), although soil temperature, water content, and drying and rewetting events must be considered in this process (5), and C:N ratios of crop residues should be noted to avoid N losses after harvest (10, 25).

pH and Electrical Conductivity (EC)

Because of the higher fruit yield in the 40 t ha^{-1} manured treatment, a higher soil pH and a lower soil electrical conductivity in 2014, it does not seem that these conditions allowed a soil denitrification (29).

The irrigation every four days applying 60% of water evaporated in this study had no adverse effects in fruit yield, because both high electrical conductivity and water-filled pored space affect positively soil denitrification (1, 6).

Conclusions

There were a better jalapeño fruit yields by using drip irrigation because of frequency of water application according to the water evaporation, therefore the first hypothesis of this research was accepted.

The 40 t ha^{-1} manured treatment had a greater fruit yield until the second year of the continuous application of this amount of manure, the other hypothesis accepted. This result could be consequence that nitrates were taken up by the plants in lower amount in the first year what it was indicated by residual amounts of nitrates in the soil.

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