Article ECORFAN Journal
June 2017 Vol.3 No.4 1-10

Response of jalapeño pepper *(Capsicum anuum L.)* Organic with drip irrigation and plastic mulch

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Received January 12, 2017; Accepted May 18, 2017

Abstract

The use of mulching with plastic allows to increase the production, accelerate maturation of the crops and improve its quality, in addition, reducing labor in different tasks such as weed control and irrigation. The objective was to determine the feasibility of the production of jalapeno pepper using compost under a production system with plastic mulching and drip irrigation. The work was realized at Rancho Borundas in Tototlán Jalisco. The treatments were: 1) without mulching, without compost and drip irrigation (control). 2) with mulching, with compost and drip irrigation. 3) with mulching and drip irrigation without compost. Three replicates of 10 m each were used in randomized blocks, applying NPK fertilization doses at 100% of what was recommended for the control. Statistical analysis included ANAVA and Tukey's means comparison test at 5%, using the SAS program. The results indicated that there is a highly significant difference at 1% probability between treatments for performance. When comparing Tukey's mean, treatment 2 yielded 29.7 Ton / Ha significantly exceeded the control, whose yield was 12.6 Ton / Ha, while treatment 3 had a yield of 19.8 Ton / Ha. The planting of jalapeño pepper with the application of plastic mulch, with compost and irrigation with dripping allowed to obtain the best yields of the Don Benito variety.

Compost, Organic Fertilizers, Production, Inorganic Fertilizers

Citation: DE LUNA-VEGA, Alicia, GARCÍA-SAHAGÚN, María Luisa, RODRIGUEZ-GUZMAN, Eduardo, PIMIENTA-BARRIOS, Enrique and GONZÁLEZ-LUNA, Salvador. Response of jalapeño pepper *(Capsicum anuum L.)* Organic with drip irrigation and plastic mulch. ECORFAN Journal-Republic of NIcaragua. 2017, 3-4: 1-10.

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1.- Introduction

The man in the search of better alternatives of conservation of the renewable resources has tried different techniques and materials, among them the acochado with plastic in soils; Through this technique has been achieved to increase production, accelerate the maturation of crops, improve quality, reduce the number of applications of agrochemicals and fertilizers, in addition to reducing labor in different tasks including weed control and application of Irrigation (Cruz, 2000), De Luna et al. (2015).

The plastic mulch makes the production of vegetables more competitive because it generates higher yields and opportunity in the market (precocity), and increases the quality of the fruits and the efficiency in the control of weeds and in the application of agrochemicals. It also reduces soil evaporation, fertilizer percolation losses and soil compaction (Lamont, 1993, Kasperbauer, 2000). Other beneficial effects of the plastic mulch are the radiation reflection that allows to generate more photoassimilates, and the application of techniques such as transplant and fertirrigation to improve the development and yield of the crops (Tarara, 2000, Andino and Motsendbocker, 2004).

In Jalapeño chile Kirnak et al. (2003) They found that plastic mulching increased the availability of nitrogen under water stress conditions, because plastic mulching reduced the negative effect of stress by allowing a near-normal yield without moisture restriction; thus, when combining black mulch with the application of -65 kPa of water stress, the fruit production increased by 47% and the efficiency of water use by 34% with respect to the same treatment but without quilting.

In recent years, new options have been sought to increase their income, without altering the soil conditions to achieve profitability and sustainability of their properties, through the application of organic fertilizers and with an efficient use of irrigation water and plastic mulch. in new crops such as vegetables. In Mexico a great variety of types of chiles is cultivated; among them, jalapeño pepper (Capsicum annum L.) is one of the most economically important due to its wide consumption, high profitability and great demand for labor (SIAP, 2010).

Organic production in Mexico began in the 1980s in horticultural crops, which have represented a source of food throughout the history of mankind; At the moment they are conferred high dietetic value and for their versatility of consumption both fresh and processed, they obtain great importance in their interaction with man. In relation to organic fertilizers Ferreira and Santamaría (1997), he proposes the use of technologies that return the lost biological component to the soil, such as composts.

López Gutiérrez (2003) points out that quilting techniques were known long before the arrival of plastic materials and practiced using organic matter (straws) or inorganic (sand), the introduction of plastic materials has revolutionized and driven to occupy currently an area close to five million hectares worldwide.

García Díaz et al. (2005), in the spring summer 2004 agricultural cycle they prepared and mulched 64 beds 1.5 m wide by 87 meters long with black / white plastic. 16 macrotunnels of 6 * 3.5 * 87 m wide, high and long, respectively, were installed. Hungarian type güero chile was planted, cultivate Hell. The plot was irrigated with a belt and in the nutrition synthetic chemical fertilizers were used. Report that the water efficiency was 17.0 kg m-3 ha-1.

The quilting has achieved an advance of up to 15 days in the harvest with respect to the crop without quilting, an important aspect in the commercialization, since it allows to place the product in early dates in the market. Since the use of plastic mulch reduces the evaporation of soil moisture by almost 100%, it brings with it a reduction in the irrigation sheet and a greater and better distribution of nutrients in the soil; with the use of this technology the weed population is reduced and this leads to a saving in the control of them and at the same time decreases the potential population of hosts or reservoirs of pests and diseases.

For Kasperbauer and Hunt (1993), and Lamont (1992) there are three types of mulch most commercially used in the production of vegetables: black, transparent and white. The most popular is black, as it slows the growth of weeds and warms the soil in the spring. The transparent one is used mainly in cold regions, since it maintains a warmer soil environment, not very different from the effect of a greenhouse; although, it requires the use of selective herbicides to prevent the growth of undergrowth of the mulch. White provides a cooler soil temperature, and is used for crops in very hot climates.

Although black does not heat the soil as efficiently as the transparent one, it prevents the growth of weeds by blocking the entry of light and is the best option in cases where it is sought to harvest earlier (Dainello and Cutner, 1995). If an autumn crop is to be planted in excessively hot soil, reflective pads such as aluminum foil and white plastic or paper are more suitable. For Ramírez (1991), choosing the color and caliber is fundamental in the choice of plastic. Color significantly influences the temperature of the soil, the microclimate, the foliage of the crop, the development of weeds, the early harvests, the yield and quality of the fruits, the durability of the mulch, and the control of diseases.

Brown et al. (1992) indicate that it can also change the amount of light and the spectral balance achieved by the plants, with resulting effects on growth and production. In studies on the effect of the color of the mulch on the growth of the plants, it was found that they altered the color of the reflected light towards the lower surface of the foliage, which influenced the growth of the plant by modifying the relationship between the red phytochrome (Pr) and far red (Pfr). This is where the color of the plastic plays its main role, since by reflecting the desired wavelength, the producers could influence the growth of the stem and the root (Kasperbauer and Hunt, 1993).

Drip irrigation, this irrigation system consists mainly of carrying water and fertilizers, to the roots of plants through a system of plastic tapes and make them come out in the form of drops by means of specific devices called emitters. In this way it is possible to give water to the plants properly dosed in quantity and time. Daily watering is recommended or every third day; also depending on the type of soil and soluble fertilizers should be applied weekly through irrigation (Bravo and Garcia, 2000). The use of a belt for drip irrigation is to make the water resource and the nutrient application more efficient, it is an alternative that is being evaluated at the productive level of the region..

One of the main factors that limit crop production is the availability of water, as it is scarce, expensive and of low quality. Another limitation is the high production costs for manual and mechanical weeding to eliminate weeds, mainly in the early stages of crop development; an option to reduce costs and the amount of water used is the use of plastic mulch (Mirafuentes, 2000).

ISSN-On line: 2414-8830

On the other hand, nitrogenous fertilization is carried out basically with nitrate sources (Anonymous 2003), due to its greater solubility, however, these can cause damage to our organism, the problem being greater in children, because if nitrates are not harmful, they can be converted to nitrites, which in high concentrations are toxic.

One of the most important advantages of using compost is that at the doses that are used, they supply the plant with the microelements in a soluble form and in a micro-environment with a biologically favorable pH for root absorption (pH 6.5 to 7). Another advantage is represented by the fact that the beneficial microorganisms present in the compost compete for micro spaces and energy with the pathogenic microorganisms that exist in the root zone of the plant (De Luna, 2014).

1.1 Objective

With the present work, we intend to determine the feasibility of jalapeño pepper production using organic bocashi type compost under a production system with plastic mulch and drip irrigation, and propose a production methodology that allows water saving, and a higher return on investment in the short and long term.

2. Materials and methods
2.1 Location

The work was carried out at Rancho Borundas in Tototlán Jalisco.

The locality is to the east center of Jalisco, in the coordinates 20º05'00 "to the 20 ° 38'15" of north latitude and 102º39'00 "to the 102 ° 52'10" of west longitude; at an altitude of 1,800 meters above sea level. The climate that predominates is classified as semi-dry with autumn and winter semi-warm, with no well-defined winter thermal change.

The average annual temperature is 20.1 ° C and has an average annual rainfall of 820.8 millimeters, with a rainfall regime in the months of June to October. The prevailing winds are in a variable direction. The average number of days with frost per year is 12.7.

The municipality borders on the north with the municipality of Tepatitlán de Morelos; to the east with the municipalities of Tepatitlán de Morelos, Atotonilco el Alto and Ocotlán; to the south with the municipalities of Ocotlán and Zapotlán del Rey; to the west with the municipalities of Zapotlán del Rey, Zapotlanejo and Tepatitlán de Morelos. It belongs to the Lerma-Chapala-Santiago hydrological basin, Verde Atotonilco sub-basin. Its main streams are: Los Morales, El pícaro, La Peñuela, Plan Zula, Las Raíces, Tepetates and Blanco well; there is also the La Caja de Agua spring; the dams: Doodles, Coinan and San Isidro, in addition to boards used for irrigation and drinking troughs.

The territory is made up of lands that belong to the Quaternary period. The composition of the soils is of predominant types vertisolpélico and feozemháplico and luvisoléutrico. The municipality has a territorial surface of 29,285 ha, of which 9,842 are used for agricultural purposes, 15,043 in livestock activity, 2,100 are for forest use, 140 are urban land and 2,160 have another use. As far as the property is concerned, an extension of 18,566 hectares is private and another one of 10,719 is an ejido, there being no communal property.

2.2 Establishment of work

The work was established during the 2014-2015 agricultural cycle using a randomized block design with four replications. The useful plot was a groove of 1.20 m wide by 10 m long. The sowing date was the second week of June, the soil preparation consisted of a fallow and two harrow steps.

The compost was added with a spreader and with the harrow was incorporated to the soil, in both cases 1.50 Kg of jalapeño chile seeds of the variety "Don Benito" were used, which were planted directly in the ground. In the plot under organic management, ten tons of bocahi compost were used. Subsequently, a foliar fertilizer with trace elements was used, applying 4 liters per hectare making three applications during the development of the crop.

For the chemical handling treatment, the fertilization was done with the recommended formula for 120N-60P-0K chili (Castellanos et al., 2000), which was dosed in 10 equal fractions during the crop cycle, in the form of nutrient solution dissolved in the irrigation water. To prepare the nutrient solution, urea (46N) and ammonium sulfate (20.5 N) were used as sources of N, and phosphoric acid (60P) as source of P.

Fertilization was started 2 d after transplanting this amount of fertilizer is the which is commonly used in the region. Planting density was 155,000 plants per hectare. The compost was made using 50 kg of pig manure, 50 kg of grass waste obtained from pruning, dry leaves and the waste of fruits and vegetables generated in the home, 50 kg of corn silage, wasted in a feedlot, these ingredients were fermented for 21 days, the preparation was to build a "pile" from parallel layers of each of the materials, water was applied to moisten without causing runoff.

In the first three days the pile was mixed in the morning and in the afternoon and from the fourth day, it was turned only once. Finally, between 12 and 15 days the fermented fertilizer achieved its maturation, its temperature was equal to the environmental, acquiring a dark gray color, it was dry and of loose consistency after analysis.

Taking the parameters of humidity, organic matter, ash , organic carbon, total nitrogen, C / N ratio, total phosphorus, total potassium total sodium, total calcium, magnesium, pH, for chemical and physical variables, water absorption capacity, bulk density and infiltration, electrical conductivity and capillarity.

2.3 Variables

To determine the quality as organic fertilizer of the compost, the physical and chemical variables were considered.

2.3.1 Physical variables

In the physical variables, the following measurements were determined according to the Fisher et al. (2003): a) Apparent density (gr cm-3), b) Water absorption capacity (gr cm-3), c) Capillarity (gr cm-3), d) Infiltration (min.).

2.3.2 Chemical variables

Chemical variables, pH, nitrogen, phosphorus, potassium and organic matter. The physical, and chemical determinations, as well as the pH, electrical conductivity and absorbency were carried out in the Environmental and Organic fertilizers Laboratory located in the CUCBA, of the University of Guadalajara.

2.4 Physical evidence

Water absorption capacity. The determination of water absorption capacity was carried out in a pot with a capacity of 300 mL and placed on a basin. The pot was filled from the substrate to the mark (250 mL), dropping it several times to compress and filling it again until the mark, once the substrate was weighed (dry weight), water was added to the basin to a little less than the height of the pot, the pot was removed once the surface of the substrate was observed slightly covered with wáter.

ISSN-On line: 2414-8830

June 2017 Vol.3 No.4 1-10

It was left to drain all the water from the pot and later it was weighed (wet weight). At the end to determine the capacity of water absorption the following equation was applied:

% Abs = ml water / Volume of the pot * 100 (1)

Where:
ml of water = (wet weight) - (dry weight)

Capillarity. To determine the capillarity, a 300 ml pot was used. and the pot was filled with compost to the mark (250 ml.), dropped several times and re-filled to the mark, its weight was recorded (dry weight), water was added to the basin (3 cm.) and the pot was placed inside, it was removed after 15 min .; it was left to drain for 10 min. and weighed (wet weight). To determine capillarity the following equation was used:

Abs. % Vol. = Ml. of water * 100 / Volume of the pot (2)

Where: ml of water = (wet weight) - (dry weight)

Apparent density. For the determination of the density (weight / volume), a test piece of 500 ml capacity was used, to which the weight was recorded. The substrate was deposited in the test tube to 400 ml and weighed. It was shaken to reduce the empty space and level the surface and read the compacted volume. The density was determined by the following formula:

Density = (full specimen weight-empty specimen weight) (1000) / vol. compacted

Infiltration. For the infiltration test, a 300 ml plastic pot was used. The substrate was placed in the pot until 250 ml. In a test tube 100 ml of water was measured, which was added to the pot making circular movements. The chronometer was activated at the time of the water fall and stopped until it completely filtered on the substrate. The results were recorded as the infiltration time of the 100 ml.

2.5 Chemical evidences

Absorbency. 20g of screened compost was used, which was deposited in a 500 ml flask; 100 ml of distilled water was added. The flask was stirred for 15 minutes (on the AROS 160 agitator). Once the stirring time had elapsed, the samples were filtered by depositing the suspension in funnels with filter paper, the filtrate was deposited in test tubes from which 7 ml were taken. The filtrate was centrifuged for 30 minutes at 3000 rpm (Ultra 8-V centrifuge). After the centrifugation time, the samples were transferred to the spectrophotometer and the reading was taken at 640 mm. Once the reading was taken, 1 ml was taken. of each of the samples and was emptied into a petri dish with filter paper to record the stain bleed. Sampling was done weekly.

Measurement of pH and electrical conductivity (CE). For the determination of pH and CE, an empty jar without a lid was weighed, 20 gr. of substrate and were deposited in the flask, 40 ml of distilled water was measured in a test tube, the container was emptied and the flask was closed, it was stirred for 10 minutes in the agitator (AROS 160). In the suspension the pH and the EC were determined with a Hanna equipment (H1-9810).

2.6 Foliar fertilizer

Preparation of mineral organic liquid foliar fertilizer

Materials and equipment

50 kg of fresh pig manure, 9 liters of whey, 9 liters of molasses, dark plastic drums with a capacity of 200 liters with lid, 1 kg of zinc sulfate, 1 kg of magnesium sulfate, 300 g of sulphate of manganese, 300 g of copper sulphate, 1 kg of calcium chloride, 1 kg of boric acid, 50 g of cobalt sulphate, 50 g of iron sulphate.

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Preparation

In a 200 liter container (plastic with lid), 50 kg of bovine manure, 100 liters of water, one liter of whey and one liter of molasses dissolved in warm water were placed. He stirred well and let ferment for 3 days. Subsequently, every 3 days, each of the minerals was dissolved in warm water and one liter of whey and one liter of molasses was added. This mixture was added to the previous fermented, stirring well.

After all the salts had been added, the contents of the plastic container were filled with water up to 180 liters, covered and allowed to ferment for 30 days. The analyzes performed were: electrical conductivity, organic matter, pH, nitrogen, phosphorus, potassium, calcium, magnesium, manganese, cobalt, iron, copper, zinc and boron.

2.7 Treatments

The treatments were: 1) Grooves without mulching without compost and drip irrigation (control). 2) Grooves with mulch, compost and drip irrigation. 3) Grooves with quilting without compost and drip irrigation. The seed used was commercial seed of Don Benito, the back of the furrow was padded with silver / black plastic of 100 microns of thickness drilled to establish plants every 35 cm, below the padding was placed the band with emitters every 20 cm. placing this to the center of the furrow. The application of the compost was made to the sowing, incorporating it with a harrowing step.

The data were analyzed by analysis of variance for the performance factor and Tukey's means test by means of SAS.

3 Results and discussion

The results for the evaluated parameters of the bocashi type compost are shown in the following table 1.

According to the obtained results, the compost meets the requirements according to the Chilean and North American norm to be used as an organic fertilizer in the production of jalapeño peppers. With padding and drip irrigation.

Treatment	Performance/ha	
Treatment 2	21.7	A
Treatment 3	19.8	B
Treatment 1	12.6	C

Table 1 Chemical composition of compost and organic liquid fertilizer

According to the results of the analysis of variance, we can see that there is highly significant difference at 1% probability between treatments for the performance factor in kg ha-1

Determinations	**Compost**	**Foliar fertilizer**	**Composta de reference**
EC. (1: 1Ds / cm)	1.46		
pH (1: 2 in water)	8.48	3.40	
M.O. (%)	27.88	-	
Nitrates (mg / kg)	57.82	30.50	
Phosphorus (mg / kg)	498.00	300.00	
Potassium (mg / kg)	10,380	1.206 ppm	
Calcium (mg / kg)	75.96.	1,276 ppm	
Magnesium (mg / kg)	1,925	724 ppm	
Sodium (mg / kg)	18.10	421 ppm	
Copper (mg / kg)	0.98	106 ppm	
Iron (mg / kg)	1.00	37 ppm	
Manganese (mg / kg)	32.00	28 ppm	
Zinc (mg / kg)	2.89	5,614 ppm	
Boron (mg / kg)	0.44	-	
CO_3	7.84	-	
SO_4	10,003	-	
Blocks (B) Treatments (T), Experimental error (EP) Sources of variation (FV), Degrees of freedom (GL), Sum of squares (SC), Average squares (CM), Calculated F (FC), F of tables (FT).			

Table 2 Analysis of variance for the performance variable of jalapeño pepper

ISSN-On line: 2414-8830

When Tukey's means comparison test was performed for the performance variable, it is observed that the treatment 2) grooves with mulching plus application of organic compost and irrigation by drip, far surpassed to the control furrows without padding and without organic composting and drip irrigation, likewise to the treatment 3 furrows with mulch but without organic compost and drip irrigation. Likewise it is observed that treatment 3 exceeds the control furrows without mulching, nor organic compost (Table 3).

FV	GL	SC	CM	FC	FT
B	3	3.826	1.275		
T	2	255.800	127.800	12.240	9.78
EE	6	93.158	15.520		
Total	11				

Table 3 Tukey test for zucchini yield.

These results agree with those obtained by Ruiz and Torres (1988), where they found that with the application of organic compost they obtained the highest yields. The organic management offers the possibility of competing in the commercialization of the product and, additionally, it increases the fertility of the soil (Seufert et al., 2012).

By minimizing the evaporation of the soil, water availability increased and, consequently, it was possible to significantly increase the fruit yield in green and the efficiency of water use in the Jalapeño pepper. Similar results were reported by Miranda et al. (2006) and Chakraborty and Sadhu (1994).

4 Conclusions

The sowing of jalapeño pepper with the application of plastic mulch, organic compost and drip irrigation allowed to obtain the best yields of the Don Benito variety, without the application of chemical fertilizers and insecticides, in addition to obtaining a better control of weeds.

Having a smaller population of hosts, pests and diseases. Likewise, significant water savings were obtained with the use of a drip irrigation strip. With the application of plastic mulch, an advance of the crop was observed up to 10 days, which is a great advantage and a greater profitability in the short and long term, more application of organic compost and drip irrigation on conventional agriculture.

In organic agriculture, stable production stands out due to gradual improvements in soil fertility (Azadi et al., 2011), such as the increase in the amount of organic matter, microbial activity and the availability of N and P (Seufert et al..., 2012). At the same time, the environmentally friendly system strengthens social, cultural and ecological elements that allow the system to produce sustainably (Schipanski et al., 2014).

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