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Cattle manure solarization with transparent plastic to pathogens control

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ABSTRACT:

The objective of this work was to evaluate the effect of plastic cover without albedo for solarizing cattle manure in order to eliminate pathogens and to obtain a safe organic fertilizer. The treatments consisted of piles of manure with single and double cover and a control without cover. The experimental design was a randomized blocks with factorial arrangement and three replications and separation of means by Tukey test (P=0.05) analyzed with SAS statistical software. During 20 days the temperatures were registered hourly in each pile at depths of 30 and 60 cm. Five microbiological analyzes were realized in order to detect *Escherichia coli* and *Salmonella* spp in each treatment. The results showed a greater homogeneity of temperature in the piles with double covered in the vertical plane, registering 62 ºC at 30 cm and 60 ºC at 90 cm of depth; the temperature with single cover was of 61.5 ºC at 30 cm and 58 ºC at 90 cm of depth; the control showed temperature of 58 ºC at 30 cm and 47 °C at 90 cm. The microbiological results before the solarization showed the presence of *Escherichia coli* and *Salmonella* spp., but after solarization process these pathogens were detected only in the control, with a minimum effective time of solarization of 21 days. The solarization of cattle manure in piles with single and double cover is an alternative to produce an organic and innocuous compost to use it in agriculture.

Keywords:

Pathogens, *Escherichia coli, Salmonella* spp.

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INTRODUCTION

In the Comarca Lagunera manure is produced in large quantities for farming cattle milk and meat established under intensive production systems. Usually, on these farms the manure is collected and piled up in heaps, and later incorporated into agricultural soils. However, incorporating raw manure to the soil can result in serious food contamination by pathogens at this stage of production (den Anntrekker et al. 2002) and also to contaminate water sources (Fortis et al. 2009). A high number of pathogens in excreta are an indicator of high risk of contamination of both food and water for irrigation and human consumption (Mara et al. 2007). Studies have reported the vertical transport of fecal coliform in the soil surface after been amended with manure (Edwards et al. 2000). In Mexico, NOM-037-FITO-1995 (1997) establishes the treatment of manure prior to application via composting, pasteurization, drying vapor, or UV radiation in order to reduce the amount of heavy metals, fecal coliform bacteria and helminth eggs. One method that has been used successfully in agricultural soils for disinfection is solarization; a hydrothermal technique of soil cover for several weeks by a polyethylene film that has the ability to capture solar radiation and significantly increase the temperature causing physical, chemical and biological effects (Wang et al. 2006; Jayaraj et al. 2007; Scopa and Dumontet, 2007). The effect of solarization is mainly due to thermal inactivation of pathogens due to the high temperatures reached in the soil (Khalid et al. 2006) being the effect on living organisms depending on the outcome of the product of temperature by exposure time. Although the role of the inactivation of proteins in the survival of microorganisms or other living cells during solarization appears to be important, one of the most important effects of solarization is the weakening of fungal propagules by sublethal temperatures, which although they do not completely destroy pathogens, they become more susceptible to attack by antagonistic microorganisms (Wang et al. 2006). This technique offers promising alternatives to control plant diseases caused by soil microorganisms without the use of chemicals products (Ijoyah and koutatouka, 2009). Some works has implemented the solarization of small cell substrates for use in plant nurseries as a new approach to the control of pathogens, however, the effectiveness of this process requires assessments as may be incomplete in deeper soil layers or when piles of land are in the shade (Nico et al. 2003). In this sense, the objective of this study was to evaluate the use of plastic without albedo to solarize manure piles as an active disinfection method to eliminate pathogens in the cattle manure and that it complies with current legislation for use as a safe organic fertilizer.

MATERIALS AND METHODS

Geographic location.

This experiment was carried out in the year 2004 in the region known as Comarca Lagunera, which is located in the central part of the northern part of Mexico in the states of Coahuila and Durango, between the meridians 102 ° 22 'and 104 ° 47 'west longitude and the parallels 24 ° 22' and 26 ° 23 'north latitude, with an average height above sea level of 1139 m. The region's climate is classified as steppe (BS) and desert (BW), an arid climate with rains in summer and cool winters. The average annual rainfall is 230 mm and evaporation from 6 to 11 times greater than precipitation is recorded in the year. The average annual temperature is 22 º C, reaching 42 ° C in summer and 4°C in winter. The relative humidity in the region varies according to season, with 31% in spring, 47% in summer, 58% in autumn and 40% in winter (García, 1981)

Experimental site and preparation of the manure piles.

The work was carried out in the experimental field of the Facultad de Agricultura y Zootecnia (FAZ-UJED), located at km 28.5 of Tlahualilo-Gomez Palacio road, Durango. The manure used in the study was collected in the farm "The Tajito" located on the right side of the Nazas River Municipality, of Gomez Palacio, Durango. Manure was wetted (40%) in a homogeneous way and turned manually with the help of shovels. The next step was the construction of the manure piles with the following dimensions: 2 m long and 1 m wide and 1 m high. To carry out the solarization process piles were covered with plastic without albedo which had the following characteristics: manufactured by Plastoza, SA State of Mexico, whose descriptions are PLANAT 180 x 1000 / 100 (1.8 m wide, 1000 m long) and 100 µ thick and transparent.

Treatments and variables evaluated.

The treatments were: T1 = manure pile covered with single plastic cover and temperature evaluated at a depth of 30 cm, T2 = manure pile covered with single plastic cover and temperature evaluated at a depth of 90 cm, T3 = manure pile covered with double plastic cover and temperature evaluated at a depth of 30 cm, T4 = manure pile covered with double plastic cover and temperature evaluated at a depth of 90 cm, T5 = uncovered manure pile and evaluation of temperature at depth of 30 cm and T6 = uncovered manure pile and evaluation of temperature at depth of 90 cm. The experimental design was randomized blocks with factorial arrangement and three replications resulting in 18 experimental units. The mean separation test was performed by Tukey ($P \leq 0.05$) using SAS statistical software (1998). In each pile of manure and during four weeks the temperature was recorded every hour in the depths of 30 and 90 cm. Temperatures were measured with a direct temperature meter (HANNA HI-99 121).

Diagnosis of *Escherichia coli* and *Salmonella* spp.

Detection of *Escherichia coli* and *Salmonella* spp was conducted in five sampling dates: 7, 12, 17, 21 and 25 of June. The manure sampling was performed on each layer of the pile around 7:30 am. To this, a hole was done with the help of a blade tip to the corresponding height of each layer and filled a plastic container of one liter capacity and then placed in paper bag cinnamon 15 x 30 cm for transportation to the laboratory for immediate analysis. Each sample was homogenized and 30 g were taken for microbiological analysis and count by the MPN technique according to the NOM-004-SEMARNAT-2002 for *E. coli* and *Salmonella* spp., (SMARN, 2003).

RESULTS AND DISCUSSION

The results of analysis of variance showed significant difference ($P \leq 0.05$) for the average temperature in the piles and depths evaluated. **Figure 1** shows that in piles covered with plastic, the temperatures had lower variation at evaluated depths, as well as a significant increase in temperature compared to the control, which is consistent with other reports (Misle and Norero, 2001). The double cover solarization had an increase in temperature of 3% compared with a single cover to the depth of 90 cm; Russo et al. (2005) found that the effectiveness of this technique in soil is between 8 and 10% with respect to the system of placing just a single cover, confirming this the higher efficiency of energy capture by the double cover because solarization produce an increased soil temperature. With respect to the control there found a difference of 10 ° C less compared to solarized piles.

In **Figure 2,** the results showed that at depth of 30 cm the highest recorded temperature was 62 ° C while the minimum was 58 ° C, which represents a difference of 4 ° C over 24 h. In the case of double cover the highest temperature was recorded during the afternoon, the temperature rise began around 15:00 pm with a sigmoid growth curve peaking around 21 h remaining constant the temperature until 24 h and from there begins a gradual decline until noon. Double cover treatment showed the greatest variation at 30 cm depth, also in this layer was observed two trends during the period of 24 h, a linear decrease from zero hours to 16 h and after this time starts a linear ascent until 19 h where it stays for four hours until 23 h, this period show the highest temperature of the pile with about 62 º C and was the highest temperature recorded in the study.

For the depth of 90 cm (**Figure 3**), the maximum temperature was 60 ° C in the double cover and the minimum temperature was 47 ° C in the control. At this depth there was less variation in temperature of the piles. The average value of the temperature in the control, single and double cover

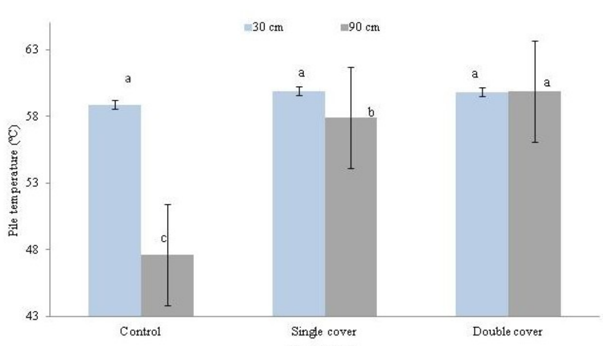

Figure 1. Comparison of means of daily average temperatures presented during the evaluation period in the piles of solarization.

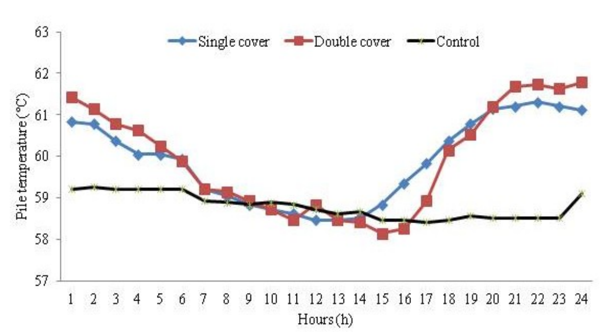

Figure 2. Average temperatures recorded in one day at a depth of 30 cm in the treatments evaluated (FAZ-UJED 2004).

reached a maximum value of 47, 58 and 60 ° C, respectively. At this depth the temperature remained without much variation. The temperature difference across strata was 13 ° C. Importantly, the temperature in the piles with plastic were similar during the 24 h, which means that the temperature remains without significant variation throughout the period; the temperature range was about 58 ° C similar to the minimum reached in the top layer, and about 3.5 º C of the highest recorded in the top layer. With reference to this double-cover treatment, the temperatures recorded during the period of 24 hours of the day were homogeneous with 60 ° C, representing a difference between layers of this pile of two degrees.

It was observed that as the days passed there was a progressive loss of moisture from the top of the pile to the lower layer, which was reflected in a decrease in temperature in the piles of solarization (**Figure 4**); similar results has been found in studies to predict the temperature in solarized soil and comparing wet and dry soils, finding that a deep of 5 cm temperature of solarized wet soil increased to 9 º C while in dry soil at the same depth increased was 5 ° C, concluded that in wet soil the primary effect of the plastic cover during the day is to reduces the effect of evaporation and to increase the amount of heat available to heat the soil (Ristaino et al. 1998; Chellemi et al. 2007). In the treatments described, was observed a significant increase in temperature in the manure piles covered with plastic.

Misle and Norero (2001), at low latitudes (Chile) found increases of temperatures in solarized soil with transparent plastic concluding that this practice can be used in unfavorable conditions of solar radiation. In this study, temperatures rose about 10 ° C than the control, noting that the amplitude between the layers 30 and 90 cm in solarized piles was two degrees Celsius. Also was observed at the depth of 90 cm in solarized piles, a minimum daily temperature variation, mainly in the piles with double plastic cover. This can be attributed to lower heat losses by radiation at night to the atmosphere due to water condensation on the inner surface of the plastic cover. Similar results have been reported by Burrafato et al. (1997) in Italy, who note that such behavior is due to the theory of heat conduction, i.e, a thermal regime in a medium is described by a monochromatic plane of the orthogonal propagation of the wave into a isothermal plane, with a dependence on the wave period and the thermal diffusivity of the medium. In Figure 4, can be observed a downward trend in the temperatures of the piles, this effect has been reported by Cebolla (2006) which states that if the soil is moist and padded with a layer of polyethylene, energy balance is changed, partly due to the moisture increases the conductivity and especially thermal diffusivity, enabling a faster warm-up to the outside, and on the other hand, there is a reduction of incident solar radiation due to the transmittance and reflection of the plastic sheet, and a marked decrease in heat loss by conduction and convection and especially removal of latent heat loss due to evaporation of a barrier imposed by the plastic. Compared with the control without plastic cover, in both strata corresponding temperature was very different, for while in the top the temperatures fluctuated around 58 ° C, the lower layer was about 47 º C, this represents a difference of about 11 ° C.

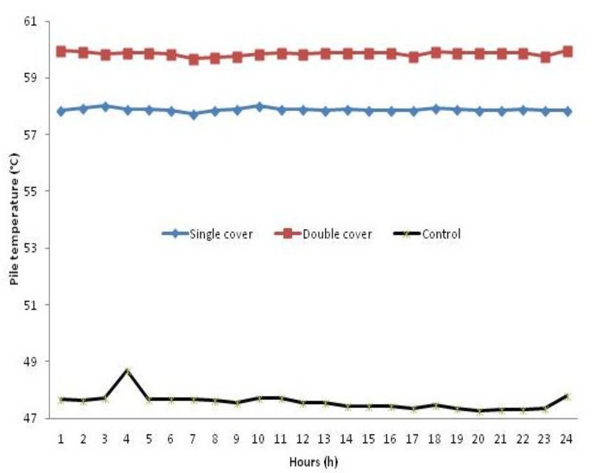

Figure 3. Average temperatures recorded in one day at a depth of 90 cm in the treatments evaluated (FAZ-UJED 2004).

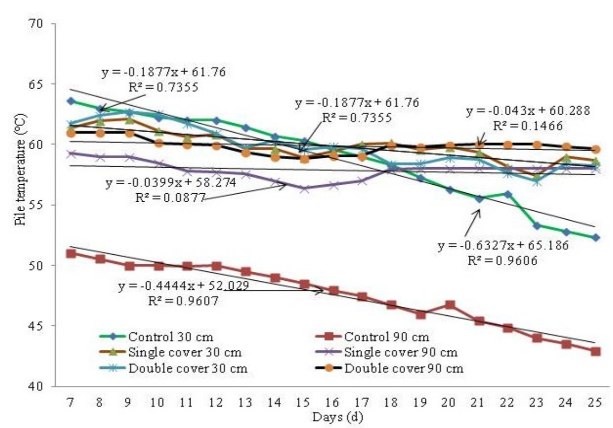

Figure 4. Performance of daily temperatures in the piles of solarization.

To evaluate the presence of organisms present in manure and their behavior in each stratum and its relationship with the temperatures, **Table 1** presents the results of the five samples and the corresponding microbiological analysis. The results of microbiological tests showed the presence of *Escherichia coli* and *Salmonella* spp., in all samples before covering piles with plastic. However, in samples collected from solarized manure with single and double plastic cover, there was no presence of these organisms after the fourth sampling. In the control treatment presence was continuous during the remainder of the experiment, being higher the number in the lower layer, where temperatures were less warm and the moisture of the manure is retained longer. Droffner and Brinton (1995) indicate that in a study of composting the temperatures were 60 ° C for three weeks, enough to kill these microbes, however, exist the possibility of re-growth of undetectable population by heterogeneity of composting in the piles; similar results were found by Velasco et al. (2004) and Noble et al. (2004), who achieved to reduce the presence of *E. coli* and *Salmonella* below the permissible values. Berry and Miller (2005), indicate that the humidity and temperatures are a contributing factor to reduce the presence of *Escherichia coli*. The high temperatures recorded in this study were higher than other studies with cattle manure under composting method. Larney and Yanke (2003) in southern Alberta Canada found that 99.9% of total coliforms and *E. coli*, were eliminated when the temperature reached 41.5 ° C, also noting that the population of heterotrophic organisms remain high, possibly producing an antagonistic effect against pathogenic organisms mentioned. Borbour et al., (2002) and Jiang et al. (2003), in studies with solarization determined the temperature that inactivates the movement of the bacteria *Salmonella enteritidis* PT4 finding that this occurs at 60 ° C. They also found that the bacterium *E. coli* which developed in culture medium and under laboratory conditions has occurred inactivation at 15 min at 60 ° C.

CONCLUSIONS

Manure solarization with plastic cover without albedo is a low cost strategy for pathogens control which should be applied previous to manure application to the soil. Under the environmental conditions of the Comarca Lagunera region, solarization of manure with plastic cover without albedo and for an exposure time greater to five days has real potential to stabilize manure by removing harmful pathogens. *Escherichia coli* and *Salmonella* spp., were found before covering piles of manure with plastic, however, in 14 days the piles with single and double cover showed no presence of these organisms. Solarization practice is assuming great significance these days in the obtaining of product free of foodborne pathogens and also in the sustainable agriculture and horticulture.

Table 1. Pathogens presents in solarized cattle manure and without solarized

Pathogen	Control		Single Cover		Double Cover	
	30	90	30	90	30	90
	June 7 (start sampling)					
E. coli *Salmonella*	$80X10^5$ MPN/g 850 MPN/4g	$80X10^5$ MPN/g 860 MPN/4g	$80X10^5$ MPN/g 810 MPN/4g	$80X10^5$ MPN/g 820 MPN/4g	$80X10^5$ MPN/g 812 MPN/4g	$80X10^5$ MPN/g 820 MPN/4g
	June 13					
E.coli *Salmonella*	$8X10^5$ MPN/g 317 MPN/4g	$8X10^5$ MPN/g 320 MPN/4g	$8X10^5$ MPN/g 208 MPN/4g	$8X10^5$ MPN/g 208 MPN/4g	$8X10^5$ MPN/g 200 MPN/4g	$8X10^5$ MPN/g 208 MPN/4g
	June 17					
E.coli *Salmonella*	≤1000 MPN/g 35 MPN/4g	≤1000 MPN/g 40 MPN/4g	<50 MPN/g <21 MPN/4g	<50 MPN/g <21 MPN/4g	<40 MPN/g <21 MPN/4g	<40 MPN/g <21 MPN/4g
	June 21					
E.coli *Salmonella*	≤1000 MPN/g 13 MPN/4g	≤1000 MPN/g 17 MPN/4g	Absent Absent	Absent Absent	Absent Absent	Absent Absent
	June 25 (last sampling)					
E.coli *Salmonella*	≤1000 MPN/g 3 MPN/4g	≤1000 MPN/g 3 MPN/4g	Absent Absent	Absent Absent	Absent Absent	Absent Absent

REFERENCES

Berry ED and DN, Miller. 2005. Cattle Feedlot soil moisture and manure content: Impact on Escherichia Coli 0157. Journal Environ. Qual., 34:656-663.

Borbour EK, Husseine SA, Farran MT, Itani DA, Honalla RH and Hamadeh SK. 2002. Soil Solarization: A sustainable Agriculture approach to Reduce Microorganisms in chicken manure-treated soil. Journal Sustasinable Agricult., 19:95-104.

Burrafato G, Cartia G and Gutkowski D. 1997. A device simulating the thermal regimens of soil solarization in laboratory experiments "summertime". *In*: Soil solarization and integrated management of soil borne pests. FAO plant production and protection paper 281.

Cebolla V. 2006. La solarización como método de desinfección del suelo. Ficha Técnica. Serie Horticultura. No.3. http://www.ivia.es/deps/otri/Documentos/FT_HOR_3.pdfv cebolla/solariza/htm. (Consultado: octubre 15 de 2007).

Chellemi DO, McSorley R, Rich JR and Steve MO. 2007. Field validation of soil solarization for fall production of tomato. Proc. Fla. State Hort. Soc., 110:1997.

Den Anntrekker ED, Boom RM, Zwietering MH and Van Schoutborst M. 2002. Quantifying recontamination through factory environments: a review. Int. J. Food Microbiol., 80:117-130.

Droffner ML and Brinton WF. 1995. Survival of *E. coli* and *Salmonella* populations in aerobics thermophilic compost as measures with gene probes. Zentralblatt für Hygiene und Umweltmedizin 197:387-397.

Edwards DR, Larson BT y, Lim TT. 2000. Runoff nutrient and fecal coliform content from cattle manure application to fescue plots. J. Am. Water Res. Assoc., 36:711-724.

Fortis-Hernández M, Leos-Rodriguez JA, Preciado-Rangel P, Orona-Castillo I, García-Salzar JA, García-Hernández J, Orozco-Vidal JA. 2009. Aplicación de abonos orgánicos en la producción de maíz forrajero con riego por goteo. Terra Latinoamericana 27:329-336.

García E. 1981. Modificaciones al sistema de clasificación climática de Koeppen. Offset Larios, S. A. México, D. F.

Ijoyah MO and Koutatouka M. 2009. Effect of soil solarization using plastic mulch in controlling root-knot nematode (*Meloidogyne* spp.) infestation and yield of lettuce at Anse Boileau, Seychelles. Afr. J. Biotechnol., 8:6787-6790.

Jayaraj J, Parthasarathi T, Radhakrishnan NV. 2007. Characterization of a Pseudomonas fluorescens strain from tomato rhizosphere and its use for integrated of management tomato damping-off. Bio Control 52:683-702.

Jiang X, Morgan J and Doyle MP. 2003. Thermal inactivation of Escherichia coli 0157: H7 in cow manure compost. J. Food Prot. 66:1771-1777.

Khalid Kh A, Yassen and SM, Zaghloul. 2006. Effect of Soil Solarization and Cattle Manure on the Growth, Essential Oil and Chemical Composition of *Calendula officinalis* L. Plants. J. of Applied Sciences Research 2:142-152.

Larney FJ and Yanke LJ. 2003. Fate of coliform bacteria in compost beef cattle feedlot manure. J. Environ. Qual., 32:1508-1515.

Mara DD, Sleigh PA, Blumenthal UJ y, Carr RM. 2007. Health risks in wastewater irrigation: comparing estimates from quantitative microbial risk analyses and epidemiological studies. J. Water Health 50:39-50.

Misle E, y A. Norero. 2001. Comportamiento térmico del suelo bajo cubiertas plásticas I. Efecto de diferentes tipos de láminas. Agricultura Técnica de Chile 61: 4-13.

Nico AI, Jiménez-Díaz RM and Castillo P. 2003. Solarization of soil in piles for the control of *Meloidogyne incognita* in olive nurseries in southern Spain. Plant Pathology 52:770-778.

SMARN. Secretaría del Medio Ambiente y Recursos Naturales. 2003. NOM-004-SEMARNAT-2002. Norma Oficial Mexicana (NOM). Protección ambiental. Lodos y biosólidos. Especificaciones y límites permisibles de contaminantes para su aprovechamiento y disposición final. Diario Oficial de la Federación

(DOF) del 15 de agosto de 2003.D.F. México

Noble R and Roberts SJ. 2004. Eradication of plant pathogens and nematodes during composting: a review. Plant Pathology 53:548-568.

Ristaino JB, Perry KB and Y Wu. 1998. Advances in temperature predictive models for soil solarization. *In*: Soil solarization and integrated management of soilborne pest. FAO Plant production and protection paper 147:463-471.

SAS (Stattistical Analysis System). 1998. SAS for Windows. Release 6.12, version 4.0.1111. Cary, N. C.

Russo GA, Candura G, Scarascia M. 2005. Soil solarization with biodegradable plastic film: two years of experimental tests. Acta Horticulturae 691:717-724.

Scopa A and Dumontet S. 2007. Soil Solarization: Effects on Soil Microbiological Parameters. J. Plant Nutrition 30:537-547.

Velasco V, Figueroa-Sandoval JB, Ferrera-Cerrato R, Trinidad-Santos A, y Gallegos-Sánchez J. 2004. CO_2 y dinámica de poblaciones microbianas en composta de estiércol y paja con aireación. Terra Latinoamericana 22:307-316.

Wang K, McSorley HR and Kokalis-Burelle N. 2006. Effects of cover cropping, solarization, and soil fumigation on nematode communities. Plant Soil 286:229-243.