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Profitability in Doses of Vermicompost for the Organic Package in Jitomate Culture, South of the State of Mexico

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Abstract: According to sustainable agriculture, the application of vermicompost is a new path to environmental protection in contrast to technological agriculture which causes pollution to the environment and organisms. The objective of this research was to verify if any treatment can replace, in the economic aspect, inorganic fertilizations based on N, P, K in tomato cultivation. For this purpose in the spring/summer 2018 agricultural cycle, five treatments were proposed, which were applied in the Cid Victoria hybrid, in greenhouse. The treatments (T) were. T1: inorganic fertilization (24 kg of N, P, K, Ca), T2: solid Vermicompost -sv- (126 kg) + liquid vermicompost -lv- (126L). T3: 208 kg: sv + 208L of lv. T4: 250kg sv + 250L of lv and T5: 416 kg sv + 416L lv. The treatments used a randomized block design in 6 repetitions. The statistical results report significant differences in two variables. Financially speaking, T3 treatment showed greater efficiency than the other treatments, with 208 kg of solid vermicompost and 208L of liquid vermicompost, since the obtained NPV fluctuated between $48,000 to $ 720,000 related to the value per kg of tomato from $6.0 to $20.0 depending on the variation thereof. BCR from 1.2 to 2.77. The breakeven point reduced its value from $12,000.00 to $10,000.00 and in a percentage from 12 to 4.

Key words: net present value; internal rate of return; sustainability, income
JEL code: E31

1. Introduction

The conventional agriculture model adopted since the fifties is based on a high efficiency production system, dependent on a high use of synthetic supplies, where monocrop management is justified as a fundamental tool to achieve greater efficiency of the production process. However, this production system has shown serious sustainability problems in twenty or thirty years of intensive use in cotton areas in Central America (Moore, 1988), and in many other areas of both irrigation and season crops, causing the destruction of natural resources, groundwater table contamination and, in consequence, human health problems due to the use of agrochemicals.

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With the aforementioned agriculture model, Mexico is the world's leading supplier of tomatoes with a 25.11% share of the value of world exports. In the 2003-2016 period there was a reduction in planted areas but the accumulated growth of production reached 54.25% and, in fresh exports, it reached 77.87%, thus being one of the crops with the greatest increase in productivity (Sagarpa, 2007).

Tomato productions in Mexico satisfy 100% national requirements and world exports have increased by 39.41% in the last decade, which has generated an increase in Mexican exports mainly to the United States of 90.67%.

Tomato yields in the US are 484 t/ha (24.2 t in 500 m^2) and in Mexico, 170t/ha (8.5 t in 500 m^2), where a gap that has yet to be filled in Mexico is evident (FIRA, 2007). The country has a record of 150,000 tomato producers, who contribute to generate 70,000 direct jobs related to this activity and the cultivated varieties are saladette and ball, mainly. In addition to this, it is the third export product after beer and avocado.

Currently, it is estimated that the horticultural greenhouse area in Mexico amounts to 1200 hectares, and that the majority is used for tomato production (Bastida & Ramírez, 2002). In the State of Mexico this area has also grown. In this scenario, the State of Mexico has also increased its area under greenhouse, there are 155 hectares under greenhouse in the State of Mexico, including the North and South regions, and there are 33,600 ha of vegetables including tomato plantings (Sánchez, 2014).

The application of vermicompost in tomato cultivation is considered a sustainable form of production for the crops and for the environment, as well as to reduce the environmental impact of inorganic fertilization. The use of vermicompost, generated from various organic wastes, has increased in different regions of the world as a high quality fertilizer (Santamaría et al., 2001; López et al., 2005).

The aforementioned is based on the growing demand for foods, which requires the use of production techniques that allow a more efficient and sustainable use of resources (Cruz et al., 2003). Vermicompost, or earthworm humus, is used as a soil improver in horticultural crops and as a non-polluting substrate (Urrestarazu et al., 2001).

Vermicompost contains active substances that act as growth regulators, has a high CEC, as well as a high content of humic acid. It also has a high moisture retention capacity, high porosity that facilitates the aeration and drainage of soil and means of growth (Orozco et al., 1996; Ndegwa et al., 2000; Castillo et al., 2000).

Vermicompost manufacturers have not presented statistical evidence of the technical recommendations regarding quantities to be applied, as well as of the study of the financial indicators that ratify their recommendations.

With the previous background, a profitability analysis was implemented to carry out this work, which consisted of calculating a series of economic indicators, based on the income and expenses obtained or projected over a given period of time. These indicators allow us to observe the degree of utility or gain that will be obtained with the application of vermicompost doses, as part of the integration of the sustainable organic package for the south of the State of Mexico. The hypothesis that arises is that at least one treatment of vermicompost has high yields and BCR with various recoveries in relation to the money invested.

2. Materials and Methods

This research was carried out under greenhouse conditions at the Universidad Autónoma Del Estado de México "el Salitre" Ranch, located in the municipality of San Simón de Guerrero. This municipality has a total population of 6,627 inhabitants INEGI (2010). It is located in the southern portion of the western section of the entity, slightly southwest from the city of Toluca and belongs to the Tejupilco region IV. It is located at 19°01'21" north longitude and 100°00'24" west longitude from the Greenwich meridian (Coespo, 1996).

It has a territorial extension of 129.23 square kilometers and an average height of 2,552masl (meters above sea level). Its boundaries are: to the north with the municipality of Temacaltepec, to the south with Tejupilco; to the east with Texcaltitlán and to the west with Tejupilco. The municipality is integrated by the municipal head, nine delegations and twelve rancherias.

A determinate hybrid tomato, Cid Victoria, was used. It was planted with root ball and with an average size of 10 cm tall. The transplant was carried out from trays to greenhouse soil on February 25th, 2018. The treatments were distributed in a randomized block design with six repetitions. The experimental parcel was 5 m long and 1.2 m wide with double row planting to give 6.0 m^2, 26 plants per parcel. Vermicompost doses were calculated in relation to the required amount per plant and were applied surrounding each plant in two applications, 1st solid vermicompost application Mar/10/2018, 1st liquid application Mar/24/2018, 2nd liquid application Apr/6/2018, 2nd solid vermicompost application Apr/26/2018.

In relation to irrigation, there were a total of 18, from planting to the last harvest in quantities of 800L each. Whitefly was controlled with still chemical sprays and there were three applications with fungicide in order to control blight and powdery mildew.

Raffia guides were placed to hold the tomato plant, alongside plastic rings, this was done on March 14th, 15th and 16th.

2.1 Project Proposed Phases

Phase I: Experimental design with solid and liquid vermicompost doses.

Phase II: 2nd cycle of organic doses; 1st year: Organic insecticides and fungicides test.

Phase III: 3rd cycle of vermicompost doses, 2nd evaluation of organic insecticides and fungicides.

2.2 Nutritive Solutions

Nutritional components of both solid and liquid vermicompost were determined on laboratory, such nutrients are shown on Table 1.

Table 1 Nutritional Components of Vermicompost Used in the Experiment With Tomato, "El Salitre" University Ranch UAEM Temascaltepec, Mex. 2018

Nutrient	N	N	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn	Mo	PH	cE
Unit	mg-kg	mg kg	Mg kg	Mg kg	Mg kg	mg kg	mg kg	mg kg	mg kg	mg kg	mg kg	Mg kg		
Solid Vermicompost	63	48	46	31	207	24	41.5	53.2	9.16	46.4	40.3	58.3	7.4	2.21
Liquid Vermicompost	65	49	52	45	249	35	44	55	8.17	48.3	46.7	61.0	7.5	2.34

Treatments

Treatment 1 (Control) 24 kg… Chemical fertilization

Treatment 2… 126 kg of solid Vermicompost + 126 L of liquid Vermicompost

Treatment 3… 208 kg of solid Vermicompost + 208 L of liquid Vermicompost

Treatment 4… 250 kg of solid Vermicompost +250 L of liquid Vermicompost

Treatment 5… 416 kg of solid Vermicompost + 416 L of liquid vermicompost

For each treatment 6 fractions of land were used divided into plots of 5 meters

5 treatments with 6 repetitions.

Experimental plot length: 5 meters.

Plots total 30 (6 treatments, 5 repetitions)

Tomato plant, every 0.38 cm, double row

Study Variables

Administrative variables

• Fixed costs
• Variable costs
• Total costs

Financial indicators

NPV, IRR, BCR, breakeven point.

These were calculated according to the tomato crops variation of prices per week or month, indicated by the National Market Information System (NMIS), during the productive period of tomato cropping.

2.3 Variable Processing

Data was submitted to NPV, IRR, BCR and breakeven point financial formulas.

Data was analyzed using analysis of variance using SAS (Statistical Analysis System version 6.12, 1998), the medians were compared via Tukey test to one ($P \leq 0.05$).

3. Results

The analysis of variance for the pH variable indicated a non-significant effect (P < 05), with a coefficient of variation of 5.02 and an average of 5.53. This is a slightly acidic pH suitable for tomato cultivation. Triddle (2017) recommends a pH between 6.0 and 6.8, so it is considered a factor to control in future experiences.

Carbon dioxide (CO_2), temperature, relative humidity and solar radiation are the main factors that determine the speed of the photosynthetic process in plants, and therefore its growth and productivity. The current concentration of CO_2 in the atmosphere is 350 to 400 ppm, while the concentration that allows the highest rate of photosynthesis in plants is that which ranges from 900 to 1000 ppm (Intagri, 2018). This means that the potential carbon assimilation rate is limited by the current concentration of this gas. Measurements and analysis of variance for this variable with vermicompost doses indicated an average of 348.5 ppm of CO_2 (Table 2), for the different treatments, although this value is considered non-limiting for the cultivation. CO_2 is therefore considered as one of the factors that is less considered by the producer.

Table 2 Statistical Results of Variables With Doses of Vermicompost in the Tomato Cultivation, Temacaltepec, Mex., 2018

Variable	Mean Square	Sum if Squares	Variation coefficient	Median	F-value	P > F
Yield/Ha	28522.4655	114089.8619	26.05	459.49	1.99 NS	0.1350
Yield/500 m^2	71.3911667	285.5646667	22.97	22.97	1.99 NS	0.1342
Yield/m^2	0.11871750	0.47486998	26.05	0.93	1.99 NS	0.1350
Yield/plant	15.9635753	63.8543012	26.33	10.58	2.05 NS	0.1251
pH	0.07950000	0.3180000	5.02	5.53	1.03 NS	0.4168
CO	3284.41481	29559.7333	9.18	348.20	3.35*	0.0296
Height 65 days	0.10166333	0.40665333	4.15	1.10	48.43*	0.0001
Height 130 days	0.00445833	0.01783333	3.16	2.74	0.59Ns NS	0.6754

3.1 Financial Aspect

Even with the statistical non-significance, an indicator of how profitable some of the doses can be is the use of financial indicators which show how profitable the crop is, depending on its costs and the sales value per kilogram of the tomato crop in the market.

The project variable costs, fixed costs and total costs of vermicompost for each treatment applied are shown in Table 3.

Table 3 Fixed Costs, Variable Costs and Total Costs in Vermicompost Treatments San Simón de Guerrero, State of Mexico, 2018

	T1	T1	T3	T4	T5
Fixed	$	$	$	$	$
Management and sales	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00
Building maintenance	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00
Equipment maintenance	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00
Electricity bill	480.00	480.00	480.00	480.00	480.00
Water bill	210.00	210.00	210.00	210.00	210.00
Subtotal					
Variables					
Control of pests and diseases	4,295	2295	4,295	4,295	4,295
200 cell seedling trays	0	0	0	0	0
Fertilizers	286	12,990	16,280	19,410	32,275
Soil preparation and planting	3,200	1400	3,200	3,200	3,200
Labor	4,600	3200	4,600	4,600	4,600
Subtotal	12,381	1,9885	28,375	31,505	44,470
Total	21,571	29,075	37,565	40,695	53,660

The basic concepts in each type of cost were considered, noting that the fertilizer costs for treatment 1and treatment 2 to 5 include liquid and solid vermicompost.

Table 4 shows the variations of the financial indicators for the variable value of kilogram of tomato in the weeks the experiment was conducted.

Table 4 shows the behavior of financial indicators as the price per kilogram of tomato increases indifferent weeks; at a price of six pesos per kilogram of tomato, treatment 3 obtains a NPV of $48,124.00, with an IRR of 16.75%, a BCR of 1.12, and a breakeven point of 12%. At the end of the price variation, with a price of 20 pesos per kilogram, treatment 5 reaches the highest NPV741,132.00, with an IRR of 88.75%, a BCR of 2.54 and a breakeven point at 4%.

In the intermediate price of 10 pesos per kilogram the following result is obtained, treatment 3 imaintains a higher value than the other treatments in the NPV ($235,000.00), an IRR of 34.53%, a BCR of 1.59, and 8% breakeven point.

In Table 4, it can be noted that as the value of the tomato price in pesos increases, the value of the BCR increases to almost 2.78-2.77 in treatments 2 and 3. And the breakeven point is reduced to less than 50%. The same as the NPV, as the price of the kilogram increases, the NPV rises. The results deriving from the application of liquid and solid organic matter doses were reflected in treatments 3 and 5, obtaining, financially speaking, high values in the NPV indicator and BCR from 1.2 to 2.54.

Table 4 Financial Indicators in Organic Matter Treatments With Tomato Cultivation, University Ranch San SimÓN De Guerrero, 2018

Indicador Financiero	Price tomato kg (variation per week in accordance with NMIS)									
T1	6	7	8	9	10	12	14	16	18	20
NPV $	10,678.5	44,716.9	78,755.4	112,793.9	146,832.4	214,909.3	282,986.3	351,063.3	419,140.2	487,217.2
IRR %	11.57	16.43	21.00	25.59	29.95	38.13	46.36	54.11	61.64	69.01
BCR $	1.03	1.14	1.24	1.35	1.46	1.66	1.88	2.00	2.30	2.51
Pe Pesos $	11,019.43	10,824.43	10,666.99	10,537.22	10,428.41	10,256.19	10,126.02	10,024.17	9,942.32	90875.09
PE %	15	13	12	11	10	9	8	7	6	6
T2										
NPV	47,208.37	88,588.48	129,968.60	171,348.71	212,728.82	295,489.05	378,249.28	461,009.51	543,769.74	626,529.97
IRR %	16.91	22.65	28.14	33.43	38.57	48.45	57.93	67.11	67.11	76.06
BCR $	1.13	1.25	1.37	1.49	1.61	1-84	2.08	2.31	2.55	2.78
Pe Pesos $	11,771.8	11,480.5	11,247.5	11,057.7	10, 900.1	10,653.0	10,468.4	10,325.1	10,210.2	10,117.3
PE %	13	123	10	9	9	7	6	6	5	5
T3										
NPV $	48,124.32	94,843.80	141,563.29	188,282.77	235,002.25	328,441.22	421,880.19	515,319.16	608,758.13	702,197.10
IRR %	16.75	22.94	28.85	34.53	40.03	50.60	60.73	70.54	80.09	89.46
BCR $	1.12	1.24	1.36	1.47	1.59	1.83	2.06	2.30	2.53	2.77
Pe Pesos %	12,714.53	12,288.04	11,953.63	11,684.38	11,462.93	11,128.21	10,867.30	10,672.99	10,519.03	10,994.03
PE %	12	11	10	9	8	7	6	5	5	4
T4										
NPV $	32,000.39	78,719.88	125,439.36	172,158.84	218,878.33	312,317.30	405,756.26	499,195.23	592,634.20	686,073.17
IRR %	14.48	20.70	26.62	32.31	37.80	48.34	58.42	68.16	77.64	86.33
BCR $	1.08	1.19	1.30	1.42	1.53	1.75	1.98	1.21	2.43	2.66
Pe Pesos $	13,276.29	12,762.72	12,363.84	12,045.07	11,784.50	11,384.01	11,090.63	10,866.46	10,689.5	10,546.47
PE %	13	11	10	9	8	7	6	5	5	4
T5										
NPV $	12,308.41	64,367.27	116,426.12	168,484.97	220,543.83	324,661.54	428,779.24	532,896.95	637,014.66	741,132.37
IRR %	11.66	18.42	24.80	30..89	36.76	47.96	58.63	68-93	78.95	88.75
BCR $	1.03	1.13	1.24	1.35	1.46	1.68	1.89	2.11	2.33	2.54
Pe Pesos $	15,062.78	14,239.30	13,618.35	13,133.41	12,744.19	12,158.25	11,738.17	11,422.24	11,176.02	10,978.71
PE %	13	11	10	9	8	7	6	5	4	4

4. Discussion

Regarding tomato yields in 500 m^2, some experiences of tomato cultivation in several states indicate, for example, for four locations in Hidalgo (Terrones, 2008), BCR of 2.30, 2.65, 3.09 and 1.57, similar to those obtained in this experience. Ortiz (2007), in an experimental study carried out in Acoxochistlán in the state of Hidalgo, reports an IRR of 38.5% in tomato cultivation. Rucoba et al. (2006) for the south central region of Chihuahua, studied the profitability of tomato cultivation under greenhouse, based on one-year data and a 10 year estimate obtained the following results NPV = 43.263.824, BCR = 1.89, N/K = 3.86 and IRR = 32.81. Based on these indicators, it is concluded that the project is economically viable. The profitability of the greenhouse, according to the analysis, is outstanding and the greenhouse tomato has good marketing prospects.

Inifap (2007) indicates that with the integrated use of vermicompost, alongside minimum tillage andthe application of other agronomic factors, such as the application of CO_2, high solubility fertilizers, etc., yields of up to 30% higher can be achieved with tomato cultivation, with the application of organic products.

Rodríguez et al. (2007) used vermicompost to verify if it could be a complete substitute for inorganicfertilizers, in the tomato crop in development, yield and quality in the tomato crop. For this purpose, in the fall/winter 2004-2005 cycle, they evaluated four ways of organic and inorganic fertilization which were applied in the Big Beef and Red Chief genotypes grown under greenhouse conditions. The treatments were T1 = sand mixture + vermicompost (50: 50% v: v) + chelated micronutrients; T2 = sand + vermicompost (50: 50% v: v) without micronutrients; T3 = sand + inorganic fertilizers (control) and T4 = sand + vermicompost extract. The control treatment (sand + fertilizers) showed greater production, surpassing by 20% the plants of the organic treatments T1 and T4 (mixture of sand + vermicompost + chelated micronutrients and sand + vermicompost extract). The treatments prepared with vermicompost deriving from bovine manure, and inorganic ones, did not satisfy the K nutritional needs in the two greenhouse grown tomato hybrids. The advantages of organic treatments in relation to the control treatment, was to increase the content of soluble solids, number of fruits and the start of flowering 10 days before.

Meanhile, Moreno et al. (2005) found that vermicompost mixed with 12.5 and 50% sand produced similar yields in greenhouse tomatoes. In contrast, Márquez et al. (2008) recorded that with vermicompost mixtures with inert substrates at 37.5 and 50% nutritional needs of tomato cultivation were satisfied. On the other hand, Manjarrez et al. (1999) mentioned that vermicompost as a substrate allowed satisfying the nutrient demand of greenhouse crops, as well as significantly reducing the use of synthetic fertilizers.

Raviv et al. (2004) point out that the nutrients contained in the compost satisfy the requirements of

tomato in the first two months after the transplant; likewise, Raviv et al. (2005) mention that the compost covered the requirements for four months after the tomato transplant.The results presented by Subler et al. (1998) show that the best crop development (tomato) occurs with small proportions of vermicompost, between 10 and 20%. In addition to the above, Atiyeh et al. (2000a, 2000b) point out that when using more than 20% of compost in the substrate, there is a decrease in the yield of the plant. On the other hand, Tuzel et al. (2003) found yields of organic tomato in a greenhouse of 90 t ha-1 (4.5 t in 500 m^2) when fertilized with chicken manure.

One more study carried out by Cun (2008), showed that from the economic point of view the greatest net profit (8,368 pesos) and the highest BCR (1.88), was obtained in treatment 1 (2 kg/m^2 earthworm humus before transplantation), with 8 kg/m^2. The application of these products indicated that it is feasible to obtain acceptable tomato yields without the use of chemical fertilizers, which contributes to the non-contamination of the environment.

From the above authors, it can be noted that the application of vermicompost doses reaches or exceeds the doses of inorganic fertilizers, a better consistency in the fruit was also observed with the doses applied in this experiment.

5. Conclusions

Tomato production is a profitable activity with the application of T3 treatment: 208 kg of solid vermicompost and 208 L of liquid vermicompost, since the obtained NPV fluctuated between $48,000 to $720,000 in relation to the price per kg of tomato from $6.00 to $20.00 depending on the variation thereof. BCR from 1.2 to 2.77. Breakeven point from $12,000.00 to $24,000.00 and with percentage variation from 12 to 4%.

Fluctuation of tomato price in the market generated an increase in the financial indicator NPV, in the IRR value, and an increase in the value of BCR, which in this case reached 2.77. The breakeven point reduced its value from $12,000.00 to $10,000.00 pesos and also in percentage from 12 to 4%. This with the tomato prices during the period of this project.

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