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RESEARCH ARTICLE

Response to organic fertilization in mango cultivars: Manila, Tommy Atkins and Ataulfo

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Abstract

The objective was evaluating the response to mineral (230-0-300 and 230-0-0 g NPK tree^{-1}) and organic: vermicompost, bokashi and chicken manure (5 and 10 t ha^{-1}) fertilizers in soil nutrimental content (pH, MO, macro and micronutriments), trunk diameter, flowering, and yield of three mango cultivars: 'Manila', 'Tommy Atkins', and 'Ataulfo'. For soil variables were design completely random and other variables a split-plot in completely random. Differences between contents of N, K, Ca, Cu and Zn were showed in soil. Differences were showed between cultivars in trunk diameter. Flowering showed differences among cultivars and fertilizers. Regarding yield in 2010, only 'Tommy Atkins' fruits were harvested, showing differences between fertilizers and control. In 2011, were differences among cultivars and fertilizers, chicken manure and mineral fertilizers outperformed the control. In 2012, 'Tommy Atkins' outperformed 'Ataulfo'. It is concluded that chicken manure 10 t ha^{-1}, were similar to nitrogen doses on soil contents of N, K, Cu and Zn; fertilizer do not have influence in the trunk diameter; on flowering and yield, bokashi and chicken manure 10 t ha^{-1}, were similar to nitrogen doses.

Keywords: Organic production, vermicompost, bokashi, chicken manure

1. Introduction

In Mexico, there are approximately 183 892 ha dedicated to growing mango *Mangifera indica* L. (SIAP, 2013), of which 98.8 % is conventionally managed (Gomez *et al.*, 2005). This is characterized for the use of industrial pesticides and fertilizers. However, the collateral effects of this production system make its sustainability even more fragile. This makes fruit producers, researchers, and technicians look for and apply alternatives that avoid growing produce with negative effects to the environment and health. In face of this necessity, the organic approach in agricultural production is a demand, given that it looks to satisfy current social demands since society is now more concerned about what they eat and is even willing to pay more for organically grown products. Within the organic production system, it is highly important to generate technology for pest and disease control, as well as crop nutrition, since they are disciplines closely related to fruit production and quality.

There is little research regarding organic nutrition in commercial production of mango, in Mexico and worldwide. Acosta *et al*. (2003), in 17-year-old 'Haden' mango, applied an integrated technological management package which included chicken manure applications (0.75 kg tree^{-1}). The results showed a greater yield with the integrated management than in the control. In Cuba, Corrales *et al*. (2003), using 10-year-old 'Super-Haden', studied the effect of vermicompost (10, 20, and 30 kg tree^{-1}) combined with mineral fertilizer doses of N (0, 254 and 508 g tree^{-1}), P_2O_5 (0, 45, and 90 g tree^{-1}), and K_2O (0, 165, and 330 g tree^{-1}). They observed that the interaction of 10 kg of vermicompost and medium and high doses of mineral sources gave the greatest yields at 249.3 and 247 kg fruit tree^{-1}, respectively, both greater than the control. In the Dominican Republic, Santos (2007) evaluated the formula 15-15-15 NPK (1.1, 1.4, and 1.8 kg tree^{-1}) plus the addition of compost to the soil (13.6 kg tree^{-1}). His results indicate that applying 1.8 kg (once a year) and 1.3 kg (twice a year) of the mineral formula, plus the incorporation of compost, increased the mean number of fruits per tree, in 'Keitte' mango, by 17 % and 24 %, respectively, compared with the trees that were not fertilized. A research in Nigeria by Moyin-Jesu and Adeofun (2008), evaluating the effect of ash from oil palm trees, straw, and bird manure on mango tree growth (from germination to 20 weeks), showed that the application of 40 g ash plus bird manure in 10 kg of the substrate increased plant height, trunk circumference, leaf area, number of leaves, and root length by 22 %, 24 %, 1 %, 27 %, and 10 %, respectively, when compared against the application of the formula 15-15-15 NPK for every 10 kg of substrate. More recently, in a research in Egypt by Abd El-Motty *et al*. (2010) evidence that using algae extract (2 %) plus yeast (0.2 %) as foliar fertilizers on the 'Keitte' cultivar increased fruit yield and quality, with regard to the control.

It has been appreciated that the organic fertilizer also affects the nutritional composition of the soil, Corrales *et al*. (2003) found a higher pH, more organic matter, content P_2O_5 and K_2O content than control, when they fertilized with vermicompost (30 kg tree^{-1}), combined with a mineral doses, ten years old Super Haden trees of Orozco and Thienhaus (1997), did four applications of fertilizers over a period of 14 months: chicken manure (454 g, 908 g, 1362 g tree^{-1}) and 100 g of 15-15-15 + 100 g of urea to *Theobroma cacao* trees with two years of age; they found that chicken manure doses of 1362 g tree^{-1} had higher pH, organic matter, K, Ca and Mg, than mineral fertilizer and control. The positive influence of organic sources has been noticed in other fruit-trees. In papaya, Shivakumar, *et al*. (2012) applied manure with vermicompost and notice the differences in N, P_2O_5 y K_2O contents, against mineral fertilizer. Tapia *et al*. (2014) applied foliar and edaphic leachate of vermicompost in avocado at 6 L tree^{-1}; showing that $N\text{-}NO_3$ content in soil increase compared with 200-100-100 N, P_2O5 and K_2O doses.

The works mentioned above are encouraging by the results shown, proving the possible benefits that can be propitiated by the application of organic technological packages that include organic fertilization. This is why the objective of this research was to evaluate the effect of different sources of organic fertilization in soil properties, stem evolution, flowering and yield of three mango cultivars in the central coastal zone of Veracruz, Mexico.

2. Materials and Methods

2.1. Characteristics of the site

The research was carried out in four consecutive years (2009, 2010, 2011, and 2012) in the Cotaxtla Experimental Field (INIFAP) (18° 56' 13" N; 96° 11' 38" W), Veracruz, Mexico. The soil is vertisol pelic, with a clay texture (30 %) at a depth of 1 meter, slightly acid pH (6.5) and a terrain slope under 3% (FitzPatric, 1993). During the study period, minimum temperatures oscillated from 14 ºC (December 2010) to 29 ºC (January 2011), maximums from 26.6 ºC (December 2010) to 37.7 ºC (January 2011), and a

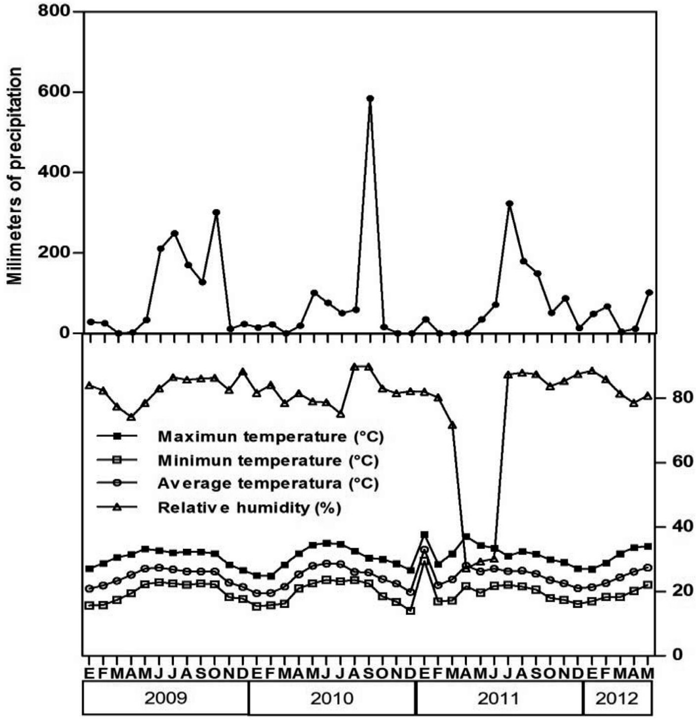

Figure 1. Climatic behavior in the central coastal area of Veracruz State.

mean temperature from 19.8 ºC (December 2010) to 33.0 ºC (January 2011). Relative humidity fluctuated between 74.2 % and 87.9 %, with exception of April, May, and June 2011, when it oscillated between 27.2 % and 30.2 %. In 2009, April and May were the driest months (2 mm); in 2010, March was the driest month (2 mm); in 2010, March was the driest month (2 mm), while greatest rainfall was in September (584.6 mm); in 2011, from February to April was present drought, while from June to November was the rainiest period (323 mm); in 2012, March did not exceed 4 mm of rain, as shown in Figure 1.

2.2. Plant material

In the present research, 'Manila Cotaxtla 2' (M), 'Tommy Atkins' (TA), and 'Ataulfo' (A) cultivars were used. The trees were established in the field in November 2006, with a separation of 6 x 2.5 m, in an area of 2,970 m^2, equivalent to 666 trees ha^{-1}.

2.3. Fertilization treatments

Three organic fertilizers were used (Table1) vermicompost (V), bokashi (B), and chicken manure (CM) in doses of 5 and 10 t ha^{-1} (equivalent to 7.5 and 15 kg tree^{-1}), they compared against two mineral doses recommended by Mosqueda *et al*. (1996): 230-0-300 and 230-0-0 g NPK tree^{-1}, and a control; they were applied in September 2009. During that year, the applications were made in the periphery of the canopy, for which trenches were dug, approximately 20 cm wide by 10 cm deep, where the fertilizers were placed and covered. From 2010, the fertilizers were uniformly distributed in the whole area under the canopy, in the first 10 cm of depth and covered with soil. During the dry season (December to May), sheets of 54 mm furrow irrigation was applied every 20 days.

2.4. Experimental design, evaluated variables, and statistical analysis

The design was completely random for soil variables; for growth, flowering and fruits yield variables was used a split-plot in completely random, being the mango cultivars the large plot, and the fertilizer sources the small plot, with three repetitions, considering one tree as an experimental unit. In 2010 and 2011 at the south of the middle part of the top tree area, soil samples were taken at 0 to 20 cm and 20 to 40 cm. Samples were transported to Campo Experimental Cotaxtla soil lab, where was determined: pH, organic matter, N, P, K, Ca, Mg, Zn, Fe, Mn and Cu. Moreover from 2009 to 2012, the following variables were determined: trunk diameter, for which a measuring tape was used to measure perimeter and divided it by Π (3.1416); number of panicles per tree, number of fruits per tree, kilograms of fruit per tree, tons per hectare, and fruit grams per cm^2 of the transversal area of the trunk. Variance and Tukey mean separation (HSD) analyses were done with a significance level of $p \leq 0.05$ using the SAS statistical software, version 9.2 (SAS Institute Inc., 2007).

Table 1. Characteristics of three organic fertilizers used on three mango cultivars.

			mg kg^{-1}								
Organic sources	pH	MO (%)	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
Chicken manure	7.17	34.14	3220	10613	13673	1362	1361	64.72	31.78	27.2	66.28
Vermicompost	4.74	6.68	3115	214.21	3466	9010	1313	94.31	1.9	9.99	37.27
Bokashi	7.31	28.81	322	894	12356	6020	2713	35.77	4.06	19.11	53.72
			kg t^{-1} fertilizer								
Chicken manure		341.4	3.220	10.613	13.673	1.362	1.361	0.065	0.032	0.027	0.066
Vermicompost		66.8	3.115	0.214	3.466	9.010	1.313	0.094	0.002	0.010	0.037
Bokashi		288.1	0.322	0.894	12.356	6.020	2.713	0.036	0.004	0.019	0.054

3. Results

3.1. Soil fertility

The pH fluctuated between 6.2 and 6.5 in the first 20 cm depth, and between 6.4 and 6.7 in 20 to 40 cm depth. Moreover, organic matter varied between 2.0 to 2.6% at the nearest part to the surface, and from 0.9 to 1.6% in 20 to 40 cm depth; both cases showed no statistically significant differences between fertilizers. Regarding macronutriments, statistically significant differences ($p \leq 0,05$) were found only in N, K and Ca content, in the first 20 cm depth. In 2010, as regards nitrogen, doses of 5 t ha^{-1} of B was statistically equal to CM and V 10 and 5 t ha^{-1}, B 10 t ha $^{-1}$, 230-0-00 g of NPK $tree^{-1}$ and control; but superior than mineral 230-0-300 g of NPK $tree^{-1}$ (Table 2). In K were found significant differences at the second year of the assessment where doses of 230-0-00 g of NPK $tree^{-1}$ was statistically inferior to CM 10 t ha^{-1} and similar to the others fertilizers and control (Table 2). Calcium was found in very high quantities in soil; in 2010, V 10 t ha^{-1}, was statistically equal to CM and B at doses of 10 and 5 t ha^{-1} and both mineral doses; and higher than 5 t ha^{-1} of V and control (Table 2).

Table 2. Edaphic content of macronutrients in 0 to 20 cm depth, in soils with three mango varieties and managed with different fertilizers sources.

Fertilizer	2010					2011				
	mg kg^{-1}									
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
	0 a 20 cm									
Vermicompost 10 t ha-1	10.5 ab	24.2 a	289 a	3748 a	519 a	7.0 a	40.4 a	413 ab	2284 a	400 a
Bokashi 10 t ha-1	10.5 ab	19.6 a	432 a	2482 ab	511 a	10.5 a	48.2 a	565 ab	1689 a	351 a
Chicken Manure 10 t ha-1	14 ab	48.2 a	432 a	2571 ab	478 a	9.3 a	60.1 a	598 a	1966 a	275 a
230-0-300 g tree-1	7 b	18.5 a	451 a	2582 ab	394 a	10.5 a	32.4 a	542 ab	2987 a	345 a
230-0-0 g tree-1	10.5 ab	18.4 a	241 a	2475 ab	431 a	-	25.4 a	358 b	3383 a	340 a
Chicken Manure 5 t ha-1	17.5 ab	43.1 a	347 a	2508 ab	452 a	-	42.9 a	454 ab	1895 a	359 a
Bokashi 5 t ha-1	28 a	33.7 a	469 a	2474 ab	477 a	-	43.6 a	428 ab	1871 a	408 a
Vermicompost 5 t ha-1	10.5 ab	24.1 a	216 a	2325 b	414 a	14 a	36.2 a	411 ab	2330 a	384 a
Control	14 ab	18.4 a	307 a	2379 b	437 a	7.0 a	25.5 a	361 ab	1747 a	351 a
CV	36.4	45.3	27.3	12.9	8.6	39.7	28.4	14.4	51.7	31.4

Columns with the same letter are statistically equal (Tukey α =0,05). - No detected, under detection limit.

Table 3. Macronutrients content at two different soil depths, cultivated with three mango varieties and treated with different fertilizers sources.

Fertilizer	mg kg^{-1}							
	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn
	0 to 20 cm				20 to 40 cm			
	2010		2011		2010		2011	
Vermicompost 10 t ha-1	2.37 a	2.1 ab	1.5 a	1.5 b	1.6 a	0.7 b	1.2 a	0.5 a
Bokashi 10 t ha-1	1.5 ab	1.9 ab	1.7 a	2.3 b	1.2 a	1.9 a	1.6 a	0.9 a
Chicken Manure 10 t ha-1	1.9 ab	3.9 a	1.7 a	4.9 a	1.5 a	1.7 ab	1.5 a	0.7 a
230-0-300 g tree-1	1.3 b	1.1 b	1.3 a	1.5 b	1.0 a	0.4 c	1.5 a	0.6 a
230-0-0 g tree-1	1.7 ab	1.4 ab	1.7 a	1.9 b	1.5 a	0.8 ab	1.2 a	0.4 a
Chicken Manure 5 t ha-1	1.7 ab	2.8 ab	1.4 a	2.3 b	1.3 a	0.6 c	1.4 a	0.6 a
Bokashi 5 t ha-1	1.5 ab	1.9 ab	1.6 a	1.7 b	1.3 a	1.1 ab	1.2 a	0.7 a
Vermicompost 5 t ha-1	1.9 ab	1.4 ab	1.4 a	1.5 b	1.5 a	0.5 b	1.1 a	0.5 a
Control	1.6 ab	1.5 ab	1.2 a	1.3 b	1.7 a	1.0 ab	1.1 a	0.4 a
CV	16.1	33.1	26.1	27.7	30.1	30.0	21.1	41.2

Columns with the same letter are statistically equal (Tukey α =0,05).

Regarding micronutrients, significant differences were found only in Cu and Zn content. In the case of cupper, in 2010, at a depth of 0-20 cm, V 10 t ha^{-1}, was statistically similar to V 5 t ha^{-1}, CM and B 10 and 5 t ha^{-1}, 230-0-0 g of NPK tree^{-1} and control, but higher than mineral doses of 230-0-300 g of NPK tree^{-1} ($p \leq 0,05$) (Table 3). Zinc was the only one who showed statistical difference between both depths; in 2010, in the layer of 0-20 cm, mineral dose of 230-0-300 g of NPK tree^{-1} was statistically lower than CM 10 t ha^{-1} and similar to the other fertilizers and control. In the same year at 20-40 cm depth, B 10 t ha^{-1}, was statistically equal to CM 10 t ha^{-1}, 230-0-0 g of NPK tree^{-1}, B 5 t ha^{-1} and control, but higher than V 10 t ha^{-1} and 5 t ha^{-1}; the last two are located over the mineral 230-0-300 g of NPK tree^{-1} and CM 5 t ha^{-1}. In 2011, significant differences showed in the first 20 cm of depth, where CM 10 t ha^{-1}, was higher than the other fertilizers and control ($p \leq 0{,}05$) (Table 3).

3.2. Trunk diameter

Regarding Trunk diameter, differences were found among cultivars ($p \leq 0{,}05$), TA and A were statistically better than M in all four years of the evaluation (Figure 2A). When estimating annual trunk increase, it was observed that from 2009 to 2012, all three mango cultivars statistically showed the same trunk diameter; although from 2010 to 2011 A cultivar showed the greatest trunk diameter, while from 2011 to 2012 TA showed the lowest increase in trunk width (Figure 2B). The effect of the different sources of fertilization on tree vigor was null, since it did not influence trunk increase during the four years of evaluation.

3.3. Flowering

In 2010, the mango cultivars showed statistical differences in flowering ($p \leq 0{,}05$); TA was superior to M and A. In the following year, TA was overcome by the others cultivars. In the third year, TA and A showed higher flowering than M (Figure 3A). With regard to the sources of fertilization, in 2010, B and CM 10 t ha^{-1}, as well as mineral doses of 230-0-300 and 230-0-0 g NPK tree^{-1}, were statistically the same and superior to the rest of the treatments, being the control the one with the least number of panicles per tree (Figure 3B). In 2011, B 10 t ha^{-1}, the dose 230-0-300 g NPK tree^{-1}, and CM in 10 and 5 t ha^{-1} were statistically the same and superior to the rest of the fertilizers and control. In 2012, V at 10 t ha^{-1}, B and CM 10 and 5 t ha^{-1}, together with the mineral dose 230-0-0 g NPK tree^{-1} were statistically the same and superior to V at 5 t ha^{-1}, the dose of 230-0-300 g NPK tree^{-1}, and the control (Figure 3B).

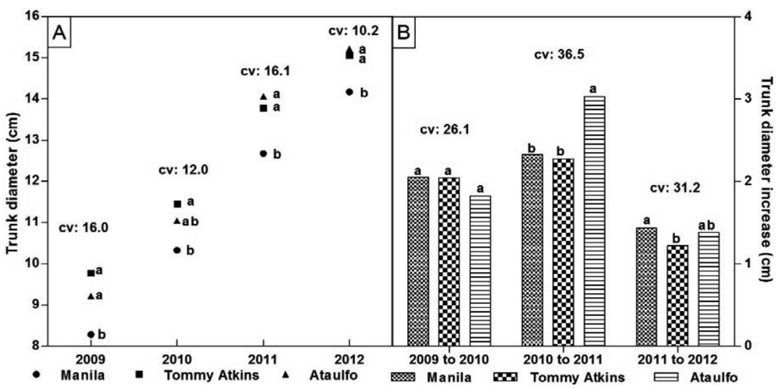

Figure 2. Trunk diameter (A) and the thickness increase (B) of the trunk in three mango cultivars fertilized with different sources. Means with the same letter are statistically equal (Tukey α =0,05). CV= Coefficient of variation.

3.4. Fruit yield

In 2010, although all the cultivars flowered, only TA set its fruits until harvest in all the experimental units, for this reason its only presented the yield of this cultivar. In this first year, CM and V 5 t ha^{-1} induced fewer fruits ($p \leq 0{,}05$) than CM 10 t ha^{-1}, and equals to the rest of fertilizers and control (Figure 4A). Regarding fruit yield per tree and per hectare, V 5 t ha^{-1}, was again overcome by CM 10 t ha^{-1} (Figure 4B and 4C). While tree efficiency, expressed in g of fruit cm^{-2} of the transversal area of the trunk, V in 5 and 10 t ha^{-1}, B 5 t ha^{-1}, doses of 230-0-300 g NPK tree^{-1} and control where overcome by CM 10 t ha^{-1} (Figure 4D).

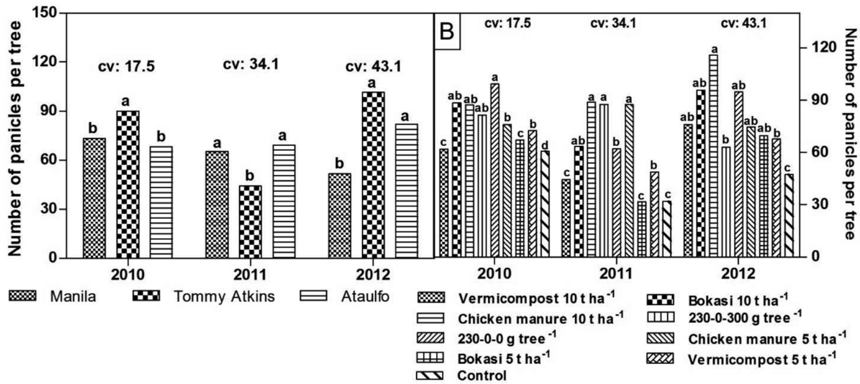

Figure 3. Flowering of three mango cultivars fertilized with different fertilizers sources during three production cycles. A) Number of panicles per tree by cultivars effect. B) Number of panicles per tree by effect of fertilization sources. Means with the same letter are statistically equal (Tukey α=0,05). CV= Coefficient of variation.

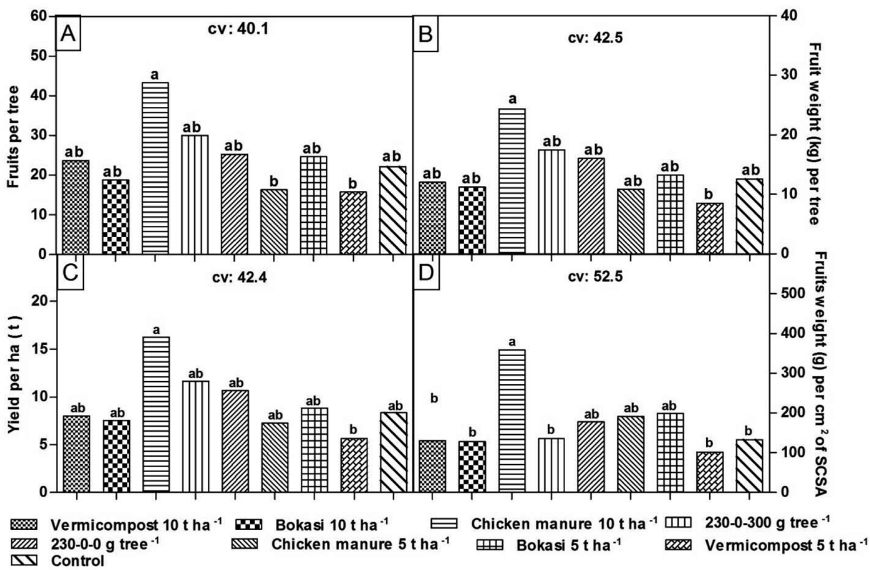

Figure 4. Yield of Tommy Atkins cultivar fertilized with different fertilizers sources in the 2010 production cycle. A) Fruits per tree. B) Fruit weight (kg) per tree. C) Yield (t) per hectare. D) Fruit weight (g) per cm^2 of transversal area of the trunk (TAT). Means with the same letter are statistically equal (Tukey α=0,05). CV= Coefficient of variation.

In 2011, differences ($p \leq 0,05$) between cultivars were observed, M produced more fruits than TA and A. In weight of fruit per tree and per hectare A was below TA and M, while in tree efficiency all cultivars behaved equal (Table 4). For the third production cycle (2012) only TA and A kept fruits on the tree until physiological maturity, in all yield parameters TA overcome A ($p \leq 0,05$) (Table 4).

Table 4. Fruit yield of three mango cultivars, treated with different fertilizers sources, for two production cycles.

	2011				2012			
Cultivars	Fruits per tree	Fruit weight (kg) per tree	Yield per ha (t)	Fruits weight (g) cm^2 of TAT	Fruits per tree	Fruit weight (kg) per tree	Yield per ha (t)	Fruits weight (g) cm^2 of TAT
Manila	38.1 a	7.6 ab	5.1 ab	15.3 a	41.94 b	10.16 b	6.76 b	720 b
Tommy Atkins	17.5 b	9.6 a	6.6 a	14.1 a	56.03 a	30.91 a	20.59 a	2007 a
Ataulfo	23.4 b	6.2 b	4.1 b	9.9 a	-	-	-	-
Fertilization sources								
Vermicompost 10 t ha-1	22.3 b	6.6 ab	4.4 ab	10.4 b	41.5 a	13.15 a	8.8 a	881.4 a
Bokashi 10 t ha-1	21.1 b	8.4 ab	6.3 ab	14.9 ab	66.0 a	20.36 a	13.54 a	1474.4 a
Chicken Manure 10 t ha-1	44.0 a	13.3 a	8.9 a	26.1 a	46.0 a	18.41 a	12.25 a	1409.3 a
230-0-300 g tree-1	46.9 a	11.7 ab	7.8 ab	18.4 ab	33.0 a	18.24 a	12.16 a	1119.4 a
230-0-0 g tree-1	31.4 ab	11.1 ab	7.4 ab	14.7 ab	61.6 a	26.88 a	17.88 a	1680.1 a
Chicken Manure 5 t ha-1	37.3 ab	10.6 ab	7.2 ab	19.3 ab	36.88 a	18.13 a	12.07 a	1425.1 a
Bokashi 5 t ha-1	9.8 c	2.7 d	1.8 d	4.4 c	63.0 a	24.48 a	16.31 a	1076.4 a
Vermicompost 5 t ha-1	19.0 b	4.9 b	3.3 b	8.1 b	40.83 a	22.91 a	15.23 a	1440.3 a
Control	11.6 c	3.9 c	2.6 c	6.8 b	56.31 a	23.93 a	15.95 a	1293.5 a
CV	40.1	48.8	48.3	52.8	40.1	45	45.0	44.1

Columns with the same letter are statistically equal (Tukey α=0,05). – No fruit was harvested.

With regard to the fertilization factor in 2011, doses of 230-0-300 and 230-0-0 g NPK tree^{-1} as well as CM 10 and 5 t ha^{-1} induced the greater number of fruits per tree ($p \leq 0,05$), than the rest of the treatments and the control. With regard to fruit weight per tree, V and B 10 t ha^{-1}, CM 10 and 5 t ha^{-1}, and doses 230-0-300 and 230-0-0 g NPK tree^{-1} were statistically equal and superior to V 5 t ha^{-1}, which was superior to the control and B 5 t ha^{-1}. In the yield per hectare B and V 5 t ha^{-1}, along with the control, showed the lowest yields. In terms of tree efficiency, V and B 10 t ha^{-1}, CM 10 and 5 t ha^{-1}, and doses 230-0-300 and 230-0-0 g NPK tree^{-1} were statistically equal and all superior to B 5 t ha^{-1}, V 5 t ha^{-1}, and the control. In 2012 fertilizer sources showed no statistically differences ($p \leq 0,05$) in fruit yield (Table 4).

4. Disscusions

4.1. Soil fertility

The pH and organic matter sameness between fertilizers and control indicate the buffer capacity of the soil, as it disable changes in this chemical properties. The results are similar with Corrales *et al*. (2003) reports; they fertilized Super Haden mango trees with vermicompost (10, 20 and 30 kg tree^{-1}), mineral doses (245-45-165 and 508-90-330 g of N-P_2O_5-K_2O tree^{-1}) and both of its; and found no significant differences between pH and organic matter between fertilized and no fertilized soils.

The results of this work differs to the reported by Corrales *et al*. (2003); they fertilized Super Haden mango trees with vermicompost (10, 20 and 30 kg tree^{-1}), mineral (245-45-165 and 508-90-330 g of N-P_2O_5-K_2O tree^{-1}) and joint implementation thereof, and found the highest contents of N, P and K with the combination vermicompost 10 kg tree^{-1} + mineral, followed by the others individual applications of each fertilizer, but all statistically difference to control. They also contrast with Moyin-Jesu and Adeofun (2008), who fertilized mango trees in nursery conditions with doses of 15-15-15 NPK, oil palm ashes, bagasse, poultry manure, turkey manure and the combination of organic fertilizers; and found that contents of Ca and Mg in soils with organic nutrition were higher to the no fertilized soils and where mineral fertilized was applied. Regarding micronutrients, results indicate that soil characteristic influenced in nutritional content, because, although the three organic fertilizers in doses of 10 t ha^{-1} were higher than mineral doses 230-0-00 g NPK tree^{-1}, they have a similar behavior than mineral dose of 230-0-0 g NPK tree^{-1} and control. Generally, was observed that P, K, Fe, Zn and Mn contents were higher in the first 20 cm depth. According to Azhar *et al*. (2007) Fe and Cu levels are classified in a medium range, will Cu and Zn are slightly above critical levels. Higher differences in the first 20 cm depth can be related to the presences of edaphic micro and macroorganism, since in this area the organic and mineral fertilizers were applied, which means available food to this organisms, and it is reflecting as higher available nutrients for plants (Jones *et al*., 1997; Lavelle *et al*., 1997).

4.2.Trunk diameter

The three growth quantified as trunk diameter, showed that the response of the trees can be influenced by their genetics, as indicated by Avilan *et al*. (2003), who noted, when evaluating three mango cultivars, that when reaching the productive stage, the trees showed strong differences in vigor. The null effect of fertilizers coincide with the observations by Corrales *et al*. (2000) who, upon evaluating de addition of chicken manure (doses of 2, 4, 6, and 8 kg plant^{-1}), mineral fertilizers, and the interaction between these in a recently established guava orchard, noted that eight months after the application of the fertilizers, the trees showed a statistical likeness in trunk width. Nevertheless, it contrasts with Orozco and Thienhaus (1997), who evaluated in cacao trees the effect of chicken manure in different doses (450, 908, and 1362 g plant^{-1}), comparing this against 100 g of the formula 15-15-15 NPK and an absolute control; they found statistical differences between organic and mineral sources compared against the control. There is no reference of the effect of organic fertilization on trunk diameter increase in mango; although there is reference to other growth variables that could be directly related with trunk increase, such as plant height and foliar area. Moyin-Jesu and Adeofun (2008) reported that the incorporation of organic sources like ash from oil palm trees, straw, and turkey and other farm bird manure, and their interactions (8 kg ha^{-1}), together with the formula 15-15-15 NPK (400 kg ha^{-1}), affected plant height and foliar area, it being statistically greater than those found in unfertilized trees.

4.3. Flowering

The results showed that mango is an alternant specie, corroborating indicated by Avilán (1974), since non cultivar showed statistical superiority in the three consecutive years. However this alternation is characterized mainly in M and A, since, even they flowering, they have no fruits in physiological maturity. The factors that could have affected fruit set were: susceptibility to disease, since on the dates of flowering and fruit set (January-March 2010), there were temperatures between 15.6 ºC and 30.5 ºC and a relative humidity between 77.4 and 84.8%, which, according to Huerta-Palacios *et al*. (2009), are conditions favorable for the incidence of *Colletotrichum gloeosporioides*; likewise the presence of wind gusts in the months of February and March may have broken down the unripe fruits; natural physiological adjustment of the tree to maintain a fruit load as a response to vigor and variety, as mentioned by Ruehle and Ledin (1955); since at the age of four years old trees do not stabilize their productive capacity. Also nutrimental factor could affected if the nutrients were no available in this particular phenological stage but they were available in fruiting growth stage or buds emission (Lovatt, 2001).

The fertilization effect is notorious because the no fertilizer trees showed the lower number, results partially differ from Ahmed *et al*. (2001), who observed that eight doses obtained from the application of N, P, and K, and their interactions, induced statistical equality in the number of panicles with the absolute control. The consistency of the effect of the CM in the years of evaluation can be attributed to the fact that this source was the richest in nitrogen, phosphorus, potassium, copper, zinc, and manganese, as compared with V and B (Table 1), resulting in greater absorption and translocation of said nutrients to the leaves of the trees, and consequently a larger pool of photoassimilates (Reddy *et al*., 2001).

4.4. Fruit yield

The lower number of TA fruits in 2011 is attributed to tree alternation, since in 2010 only this cultivar maintained its fruits until physiological maturity, contrary to M and A. In this year, even TA was inferior to M in fruit number, its yield increasing per tree and per hectare was a consequence of the individual weight of fruit, in average it was 511.5 g, while A and M average weight were 234.7 g and 185.4 g, respectively. The inferiority of A yield against M in 2011 and TA in 2012, can be attributed to the characteristics proper to the genetic material. This cultivar shows abortions in flowers and fruitlets, whose ratio con go down as far as 3000:0.01 flowers per set fruit, when the norm is 3000:1 set fruit per panicle. Besides great part of the fruits set stay on the three, they are parthenocarpic or better known as "child fruit" Gehrke (2008), and they are characterized for have less weight and size. The absence of fruit in the M cultivar could be partly attributed to an alternation effect as indicated by Avilan (1974), since in 2011 it was M that produced the greatest number of fruits. On the other hand, the climatic effects could have negatively influenced fruit set since temperatures (16.0 ºC to 28.9 ºC) and relative humidity (85% to 88.5%) in December, January and February time that coincides with flowering and fruit were favorable for the development of the causal fungus *Colleotrichum gloesporioides* (Huerta-Palacios *et al*., 2009), causing the death of flowers and unripe fruit.

With regard to the fertilization, the results differ from those reported by Sarker and Rahim (2012), and Sergent (1995), who realized edaphic applications with mineral fertilizers and both of them appreciated a higher quantity of fruits on fertilized trees, compared with the no fertilized trees. They also differ from the report by Corrales *et al*. (2003) who, fertilized 10-year-old 'Super-Haden' mango trees with V (10, 20, and 30 kg tree^{-1}), mineral doses (245-45-165 and 508-90-330 g N-P_2O_5-K_2O tree^{-1}) and the joint application; as with Corrales *et al*. (2000), who employed CM (0, 20, 40, 60 and 80 g bag^{-1}) combined with 0, 33, 66 and 100% of the dose 150-80-30 of N, P_2O_5 y K_2O; in both cases they appreciate that individuals applications of mineral and organic fertilizers where statistically inferiors to the combination of organic and mineral fertilizers, but superior to control; different from what happened in the present work, where V and CM at 5 t ha^{-1} (2010), B at 5 t ha^{-1} (2011) and all fertilizers (2012) where similar to control. From organic fertilizers, CM at 10 t ha^{-1}, was the only one who equaled de dose 230-0-0 g of NPK tree^{-1}, and outperformed the V and B at 5 t ha^{-1} and 230-0-300 g of NPK tree^{-1} in two of the evaluation years; it is attributed to higher contents of N, P and K, which according to Reddy *et al*. (2001) are directly related with flowering and fruit yield. Is important to note that there are reports about high contents of heavy metals in poultry manure and fertilizer manufactured with urban solids residues, that can affect edaphic biology, contaminate water tanks and even translocate to the aerial parts of the plant if they are deposited on the ground (Liao y Xie, 2007; Rodríguez *et al*., 2012; Delgado *et al*., 2014), therefore it is recommended compost it because organic matter is stabilized and facilitates the use of the properties of the manure fertilizer (Estrada, 2005).

5. Conclusions

Of the organic fertilizers only CM 10 t ha^{-1} were superior to mineral dose 230-0-300 g NPK tree^{-1} in edaphic contents of N, K, Cu and Zn. Moreover TA and A cultivars showed the largest trunk diameter. While in flowering and yield TA was constant in the three years of evaluation and in two years it showed its highest yield per hectare. Of the fertilizers, B and CM at 10 t ha^{-1} had a similar yield to mineral dose 230-0-0 g NPK tree^{-1}, both overcome the control. According to the above, organic nutrition could substitute mineral nutrition in this fruit tree, with the added advantage that it decreases the input of synthetic materials into the soil.

References

Abd El-Motty, E.Z., Shahin, M.F.M., El-Shiekh, M.H., Abd-El-Migeed, M.M.M. 2010. Effect of algae extract and yeast application on growth, nutritional status, yield and fruit quality of Keitte mango trees. Agriculture and Biology Journal of North America. 1, 421-429.

Acosta-Ramos, M., Noriega-Cantú, D.H., Nieto-Ángel, D., Téliz-Ortiz, D. 2003. Efecto del manejo integrado del mango (*Mangifera indica* L.) en la incidencia de enfermedades y en la calidad de frutos. Revista Mexicana de Fitopatología. 21, 46-55.

Ahmed, S., Jilani, M. S., Ghaffoor, A., Wasseem, K., Rehman, S.U. 2001. Effect of different levels of N P K fertilizer in the yield and quality of mango (*Mangifera indica* L.). Online Journal of Biology Sciences. 1, 256-258.

Avilán, R.L. 1974. Cuatro años de fertilización en mango (*Mangifera indica* L.) en suelos de la serie Maracay. Agronomía Tropical. 24, 97-106.

Avilán, L., Emaldi, U., Soto, E., Rodríguez, M., Ruiz, J. 2003. Evaluación de cultivares “criollos” de mango. Agronomía Tropical. 53, 119-131.

Azhar, N., Ashraf, M.Y., Shirazi, M.U., Khan, M. A., Pervez M.A., Ahmad, S. 2007. Studies on soil and plant micronutrients relationship of mango orchards in Hyderabad district of Pakistan. Proceedings: International Symposium on Prospects of Horticultural Industry in Pakistan. 28 to 30, March, 2007, 120-125.

Corrales, G.I., López, L.P., Guerra, G.A. 2000. Uso de la gallinaza y fertilizante mineral en el guayabo (*Psidium guajaba* L.). Centro Agrícola. 27, 47-57.

Corrales, G.I., González, M., López, L.P. 2003. Respuesta del mango (*Mangifera indica* L.) a las aplicaciones de humus de lombriz con fertilizante mineral. Centro Agrícola. 30, 45-50.

Estrada, P.M.M. 2005. Manejo y procesamiento de la gallinaza. Revista Lasallista de Investigación. 2, 43-48.

FitzPatrick, E.A. 1993. Suelos. Su formación, clasificación y distribución. Compañía Editorial Continental S.A. de C.V. México. 430 p.

Gehrke, V.M.R. 2008. Reflexiones sobre problemas de biología reproductiva del mango Ataulfo en el Soconusco, Chiapas. Tecnología en Marcha. 21, 174-183.

Gómez, C.M.A., Schwentesius, R.R., Meraz, A. M. del R., Lobato, G.A.J., Gómez, T.L. 2005. Agricultura, Apicultura y Ganadería Orgánicas de México-2005. Situación-Retos-Tendencias. Ed.CONACYT, SAGARPA, CEDRSSA-CIESTAAM-UACh. México. 68 p.

Huerta-Palacios, G., Holguín-Meléndez, F., Benítez-Camilo,F.A.,Toledo-Arreola, J. 2009. Epidemiolgía de la antracnosis [*Colletotrichum gloeosporioides* (Penz) Penz. And Sacc.] en mango (*Mangifera indica* L.) cv. Ataulfo en el Soconusco, Chiapas, México. Revista Mexicana de Fitopatología. 27, 93-105.

Jones, C.G., Lawton, J.H., Shachack, M. 1997. Positive and negative effects of organisms as physical ecosystem engineers. Ecology. 78, 1946-1957.

Lavelle, P., Bignell, D., Lepage, M., Wolters, V., Roger, P., Ineson, P., Heal, O.W., Ghillion, S. 1997. Soil function in a changing world: the role of invertebrate ecosystem engineers. European Journal of Soil Biology. 33, 159-193.

Liao, M., Xie, X.M. 2007. Effect of heavy metals on substrate utilization pattern, biomass and activity of microbial communities in a reclaimed mining wasteland of red soil area. Ecotoxicology and Environmental Safety. 66, 217-223.

Lovatt, C. 2001. Properly timed soil-applied nitrogen fertilizer increases yield and fruit size of “Hass” avocado. Journal of the American Society for Horticultural Science. 126, 555-559.

Mosqueda, V.R., De los Santos, de la R.F., Becerra, L. E.N., Cabrera M. H., Ortega Z.D.A., del Angel P. A. L. 1996. Manual para cultivar mango en la planicie costera del Golfo de México. Folleto Num. 15. INIFAP. Centro de Investigación Regional Golfo Centro, Campo Experimental Cotaxtla, 130 p.

Moyin-Jesu, I.E, Adeufon, C.O. 2008. Comparative evaluation of different organic fertilizer on the soil fertility, leaf mineral composition, and growth performance of mango seedlings (*Mangifera indica* L.). Emirates Journal of Food and Agriculture. 20, 18-30.

Orozco, M., Thienhaus, S. 1997. Efecto de la gallinaza en plantaciones de cacao (*Theobroma cacao* L) en desarrollo. Agronomía Mesoamericana. 8, 81-92.

Osuna-Enciso, T., Engleman, E. M., Becerril-Román, A. E., Mosqueda-Vázquez, R., Soto-Hernández, M., Castillo-Morales, A. 2000. Iniciación y diferenciación en mango ‘Manila’. Agrociencia. 34, 573-581.

Reddy, Y.T.N., Kurian, R.M., Sujatha, N.T., Srinivas, M. 2001. Leaf and soil nutrients status of mango (*Mangifera indica* L.) grown in peninsular India and their relationship with yield. Journal of Applied Horticulturae. 3, 78-81.

Rodriguez, A.M., Muñiz, U.O., Calero, M,O., Montero, A.A., Martínez, R.F., Limeres, J.T., Orphee, M. M., Aguilar, A.A.M. 2012. Contenido de metales pesados en abonos orgánicos, sustratos y plantas cultivadas en organopónicos. Cultivos Tropicales. 33, 5-12.

Ruehle, G.D., Ledin, R.B. 1995. Mango growing in Florida. Gainesville. Agricultural Experimental Station, University of Florida. Bulletin 574, 90 p.

Santos, B.M. 2007. Effects of adding compost to fertilization programs on ‘Keiit’ mango. Journal of Agronomy. 6, 382-234.

Saeker, B.C., Rahim, M.A. 2012. Effects of doses and splits of fertilizer application on harvesting time, yield and quality of mango cv. Amrapali. Bangladesh Journal of Agricultural Research. 37, 279-293.

SAS Institute Inc. 2007. SAS OnlineDoc® 9.2. Cary, NC: SAS Institute Inc.

Sergent, E., Casanova, E., Leal, F. 1995. Aplicación de nitrógeno y potasio en mango *Mangifera indica* L. Agronomía Tropical. 45, 293-312.

Shivakumar, B.S., Dharmatti., Channal H.T. 2012. Effect of organic cultivation of papaya on yield, economics and soil nutrient status. Karnataka Journal of Agricultural Sciences. 25, 488-492.

SIAP (Servicio de Información Agroalimentaria y Pesquera)-SAGARPA (Secretaria de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación). 2013. Cierre de la producción agrícola por estado.

Tapia, V.L.M., Larios, G.A., Hernández, P.A., Herández, P.A., Guillen, A.H. 2014. Organic nutrition of avocado cv. "Hass" and nutritional and agronomic effect. Revista Mexicana de Ciencias Agricolas. 5, 463-472.