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RESEARCH PAPER

The influence of organic fertilizers on the chemical properties of soil and the production of *Alpinia purpurata*

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Abstract

M.I. Saldaña y Hernández, R. Gómez-Álvarez, M. del C. Rivera-Cruz, J.D. Álvarez-Solís, J.M. Pat-Fernández, and C.F. Ortiz-García. 2014. The influence of organic fertilizers on the chemical properties of soil and the production of Alpinia purpurata. Cien. Inv. Agr. 41(2): 215-224. Organic fertilizers are an important contribution of organic matter that modify the physical, chemical and microbiological characteristics of the soil. To determine the impact of solid and liquid fertilizers on Alpinia purpurata, the nutritional characteristics of the soil and the responses of the plants were evaluated at 40 and 365 days in Medellín and Madero and Ignacio Allende, Tabasco, Mexico. The treatments were compost, vermicompost, fermented manure, Bokashi, liquid humus (6 Mg·ha-1 and 60 L·ha-1), chemical fertilizer (150-50-250) and the control. The experimental design was completely randomized blocks with three replications for each treatment. The experimental unit was a stump with stems of A. purpurata. For the soil, the concentrations of organic C, total N, available P and exchangeable K were determined. For the foliage, N, P and K contents were determined. For the stump, the number of stems, the commercial and the noncommercial biomass were determined. For the stem, length, diameter, flower diameter and flower length were determined. Fertilized soils had an increase in C (40%), N (47%), P (83%) and K (56%) after 40 days. One year after the addition of fertilizers, the soils maintained acceptable nutritional levels for production. The Bokashi fertilizer increased the concentration of P (9.5%) and K (8.3%) in the foliage of plants from Medellín and Madero. Liquid humus increased N (16%) in the foliage from Ignacio Allende. When fertilized with fermented manure and compost, the plants increased the number of stems (35.3%), total biomass (35.5%), stem length (19.2%), stem diameter (16%), flower diameter (9.5%), and flower length (12.3%).

Key words: Bokashi, compost, fermented manure, macronutrients, red ginger, vermicompost.

Introduction

Organic fertilizers are an ecological alternative to increase fertility and crop production in sustainable agroecosystems (Wu *et al*., 2005). Their use improves the physical, chemical and biological characteristics of the soil (Ingelmo and Rubio 2007; Vargas and Suárez, 2007), even though they are lower in nutrients compared with inorganic fertilizers. Nitrogen (N) content in composts is 1 to 3% and the N mineralization rate is approximately 10% (Sikora and Enkiri, 2001). Therefore, only a fraction of N and other the nutrients are available the first year after the application. However, organic fertilizers may be

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substituted for chemical fertilizers and improve the characteristics of cultivated vegetables (Rodríguez *et al*., 2009; Cruz-Castillo *et al*., 2008). The capacity of organic fertilizers to supplement nutrients to crops depends on the properties of the raw material of the organic fertilizer, the preparation process, the degree of mineralization of the materials, and the dominant conditions in the field for subsequent decomposition (Evanylo *et al*., 2008). The red ginger *Alpinia purpurata* (Vieill.) K. Schum. is an outstanding crop with yearly production in tropical and subtropical regions worldwide, providing important incomes for producers (Kent *et al*., 2007). *A. purpurata* produces cut flowers throughout the year, which suggests a permanent extraction of soil nutrients that will affect its productive capacity. In Mexico, the states of Chiapas, Tabasco and Veracruz are known for their cultivation of *A. purpurata* (Baltazar and Figueroa, 2009). The largest sowed surface of *A. purpurata* in Tabasco was found in the municipalities of Centro and Teapa (Saldaña *et al*., 2013). Although the use of organic fertilizers is generally recommended for *A. purpurata* production (Texeira and Loges, 2008), conventional management of the species is most often practiced and it includes the use of high doses of chemical fertilizers. A complete fertilization is suggested once a month or 3 to 6 times a year in proportions from 1:1:1 to 3:1:5 of N-P-K to increase flower production and quality (Kent *et al*., 2007). Nitrogen, P, and K content in foliage are good indicators of the nutritional status of *A. purpurata*, with 2.0%, 0.16% and 1.8%, respectively (Kent *et al*., 2007). The use of synthetic fertilizers causes technological dependence, increases production costs, decreases soil organic matter (OM) and the capacity for water storage, and alters soil structure and soil pH (Dudgeon *et al*., 2006). Maintaining the productive capacity of the soil requires practices that improve soil and crop nutrition and requires proper management of nutrients and organic matter to avoid their loss and to optimize the edaphic variables linked to conservation. The objective of this research was to evaluate five organic fertilizers as sources of available macronutrients for the production of *A. purpurata* in two localities in Tabasco for a year.

Materials and methods

Experimental sites and physical and chemical properties of the soil

Two experiments were conducted under field conditions for one year, beginning on April 19, 2011. Experiment one (site 1) was in Medellín and Madero, 3rd section, Centro, Tabasco, and experiment two (site 2) was in Ignacio Allende, 3rd section, Teapa, Tabasco.

Site 1 is located at 18º 06’ 40.7”N and 92º 50’ 48.2”W and is 11.7 meters above sea level (masl) in climate zone Am(f). The annual mean temperature is 26º C with an annual pluvial precipitation of 1500 mm. Maximum precipitation occurs in August, September, and October, and minimum precipitation occurs in March, April, and May (INEGI, 2001). This site has been cultivated with cedar, *Cedrela odorata,* and mahogany, *Swietenia macrophylla*, with a 4x4 m area between the trees. Ginger was sown 5 years ago in the intermediate spaces in 2×4 m areas between the plants (1,250 plants per hectare).

Site 2 is located at 17º 35’ 59.2”N and 92º 59’ 29.6”W and is 18.0 masl with a warm-humid climate in zone Af(m)w”(i´)g. The mean annual temperature is 26º C with an annual pluvial precipitation of 4000 mm. Maximum precipitation occurs in the fall, and minimum precipitation occurs in the spring (Arreola *et al*., 2011). This site has been cultivated with cocoa (*Theobroma cacao* L.) with a 4×4 m area between the trees. Ginger was sown two years ago in the intermediate spaces in 1.5×1.5 m areas between the plants (4,444 plants per hectare). The soil is a eutric fluvisol, and it is distributed parallel to the rivers and streams throughout Tabasco and is the soil considered to be the best in the state. The soil is deep with good permeability and is medium to coarse-textured with poorly developed horizons (horizons A and C). The soil is rich in nutrients and organic matter.

Organic fertilizers

The organic fertilizers evaluated were as follows: compost, vermicompost, fermented manure, Bokashi and liquid humus. The compost was composed of *Heliconia* and *Alpinia* crop residues, *Gliricidia sepium* green foliage, *Capra aegagrus hircus* manure, soil and water. These components were mixed in 3:1:1:3 v/v proportions (vegetable:manure:soil:water). The vermicompost was produced with the redworm, *Eisenia andrei*, fed with ovine manure. Liquid humus was obtained by leaching the vermicompost, mixed with water in a 1:1 ratio (vermicompost:water). Then, the liquid phase was decanted and contained. Manure was obtained from sheep fed with *Cynodon plectostachyus* supplemented with mineral salts, and then, the manure was fermented for 120 days, covered from the sun and rain. Bokashi was prepared with foliage from *Gliricidia sepium* and graminae hay, Pelibuey sheep manure, soil, vegetal coal, yeast, molasses, lime and water; the proportions were 5:5:5:0.5:0.0125:0.04:0.09:1 (w/w), respectively. Bokashi was fermented for 20 days until it became dark brown and the temperature stabilized at 32º C. The physical and chemical characteristics of the fertilizers were determined using the methodologies described in NOM-021-RECNAT (DOF, 2002) and are presented in Table 1.

Experimental design

The experimental design was randomized complete blocks with seven treatments and three repetitions for each site. The blocked factor was the slope of the land. The experimental unit was a stump of the plant *A. purpurata*, composed of stems with flowers and stems in the vegetative stage. The treatment factor was organic fertilizer, with an application of 6 $Mg \cdot ha^{-1}$ for solid fertilizers and 60 $L \cdot ha^{-1}$ for the liquid humus. The fertilizers were applied to the soil surrounding the experimental units at 20 cm from the plant base and 15 cm deep. The treatments were as follows: control (T), compost (C), vermicompost (V), fermented manure (FM), Bokashi (B), liquid humus (LH), and chemical fertilizer (Q). Nitrogen, P, and K sources of the chemical treatment (150-50-250) were urea (46% N), diammonium phosphate (46% P_2O_5), and potassium chloride (60% K_2O), respectively. The N was applied in three equal amounts (May, August, December), and the other two nutrients were applied in one application in May.

Production of plant biomass and flower quality

The plant biomass that accumulated in 52 weeks was quantified in each experimental unit from both sites. The floral stems reaching the harvest stage were counted, cut, and measured (flowers with three-quarters of their bracts open). Flowers reached commercial size when $\geq$ 20 cm long. Each harvested floral stem was divided into commercial

Table 1. Physical and chemical characteristics of organic fertilizers.

Organic fertilizers	pH	OM	C	N	C/N	P Olsen	K	Ca	Mg	NH_4^+	NO_3^-
	1:2		%			mg kg^{-1}		cmol kg^{-1}		mg kg^{-1}	
Compost	7.7	20.00	11.59	0.8	14.5	4.72	5.91	3.88	4.77	79.57	125.23
Bokashi	8.0	36.70	21.27	1.8	11.8	10.16	12.30	7.09	12.00	63.27	627.43
Vermicompost	8.2	45.40	26.32	2.0	13.2	10.30	8.95	8.38	22.50	60.00	545.91
Ferm. Manure	7.9	56.80	32.90	3.8	8.7	13.16	30.10	2.09	19.90	60.00	3309.70
Liquid Humus	8.0	3.15	1.55	4.9	0.3	26.00	0.18	0.20	15.40	SLMD	18.94

SLMD=Smaller than the detection limit of the method. Ferm.=fermented, OM=organic matter, C=organic carbon, N=total nitrogen, C/N=ratio of carbon to nitrogen, P=available phosphorus, K=exchangeable potassium, Ca=calcium, Mg=magnesium, NH_4^+=ammonium, NO_3^-=nitrate.

and noncommercial portions; the commercial portion included the flower, three apical leaves and 80 cm of stem, and the noncommercial portion was the foliage and the basal portion of the stem. Each portion was weighed and the dry biomass was determined for the stem samples with flowers (commercial and noncommercial portions). These samples were dried in an oven (CRAFT Scientific Instruments, U.S.A.) at 60 °C until they reached a constant weight. The weight was determined on an OAHUS grain scale. Production variables were as follows: the number of commercial stems per plant (NS), the commercial stem biomass (CB), the noncommercial stem biomass (NCB), the total biomass (TB), the stem length (SL), the stem diameter (SD), the flower length (FL) and the flower diameter (FD).

Foliar analysis

For the foliar analysis, four leaves, the 4th leaf per floral stem, were collected per experimental unit at the end of the experiment. Total N was determined by the microkjeldhal method with sulfuric acid digestion, available P was determined by UV, and exchangeable K was determined by acid digestion and atomic absorption spectrophotometry.

Statistical analyses

An analysis of variance, mean comparisons (Duncan, P≤0.05), and correlations (Pearson) were performed with the data. The SAS software (SAS system, V9, Institute Inc., Cary, NC, USA) was used for the statistical analyses.

Results and discussion

Available organic carbon and nutrients in the soil

The fertilized soils had higher organic C contents than the control soils after 40 days (Tables 2 and 3). The soil with the Bokashi fertilizer had the highest C content (4.02%). The soil organic C content was 40% higher in the Bokashi treatment than in the control at site 2 (P≤0.05). Similarly, Rivera-Cruz *et al*. (2010) found a 94% increase in the organic content of soils that received an application of 3% chicken manure compared with the control. The fertilizers increased the levels of C in the soil, which leads to an increase in fertility because of an increase in microorganism activity using C as energy source (Vargas and Suárez, 2007).

Compared to the control, organic fertilizers also increased the N content in soils. The largest increase in soil N was with the fermented manure (0.36%) at site 1, and with liquid humus (0.31%) and compost (0.31%) at site 2. According to Wu *et al*. (2005), the application of organic fertilizer increased the N content in soil because of the

Table 2. Organic carbon and nutrient contents in the soil with organic amendments 40 and 365 days after application in Medellín and Madero, Centro, Tabasco, México.

	Organic C		Total N		Available P		Exchangeable K	
	%				mg·kg^{-1}		cmol kg^{-1}	
Treat.	40da	365da	40da	365da	40da	365da	40da	365da
T	2.1 d[1]	2.39 bc	0.19 d	0.22 bc	9.4 b	5.19 c	0.14 b	0.38 c
C	2.9 bcd	2.41 bc	0.26 bcd	0.21 bc	10.5 ab	7.58 c	0.21 ab	0.37 c
V	2.3 cd	2.25 cd	0.32 ab	0.21 bc	11.5 ab	12.49 b	0.15 b	0.50 b
FM	3.2 ab	2.87 a	0.36 a	0.26 a	16.5 a	12.09 b	0.15 b	0.34 c
B	3.4 ab	2.13 d	0.30 ab	0.20 c	10.0 b	9.82 bc	0.18 b	0.55 a
LH	4.0 a	2.38 bc	0.28 bc	0.22 bc	9.5 b	4.48 c	0.16 b	0.42 bc
Q	3.0 bc	2.35 bcd	0.23 cd	0.21 bc	10.5 ab	20.94 a	0.22 a	0.60 a

[1]Values followed by the same letter in the same column do not differ significantl (Duncan, P≤0.05) (n=3).
Treat=treatments, T=control, C=compost, V=vermicompost, FM=fermented manure, B=Bokashi, LH=liquid humus, Q=chemical fertilizer, da=days after application.

greater N and organic C concentration in the fertilizer.

The available P content in soil increased significantly with the application of fermented manure compared with the control, from 9.4 to 16.5 mg·kg^{-1} at site 1 ($P \leq 0.05$).

Soil potassium increased from 0.14 to 0.21 cmol·kg^{-1} at site 1. Significant differences were observed for the chemical fertilizer, which increased the K content in soils 36% and 40% at sites 1 and 2, respectively ($P \leq 0.05$). The addition of K as KCl at 125 mg kg^{-1} of soil or higher increased the activity of exchangeable K in vertisol soils. Additionally, the soils had sufficient concentrations of K to supply cultivation demands; however, the regular use of K fertilizer is recommended to maintain sufficient concentrations in the soil (Zúñiga-Estrada *et al.,* 2010).

One year after treatment application, the organic C and total N contents in the soil tended to decrease. According to Gosling *et al*. (2006), organic matter, organic C and soil nutrients in tropical humid regions decreased because of high microorganism populations and leaching caused by abundant rainfall. At site 1, the fermented manure was the treatment that preserved the most organic C, total N and available P in the soil ($P \leq 0.05$) (Table 2). At site 2, the organic C in the soil was similar among the treatments after one year.

The average total N content decreased up to 16% after 365 days with the use of organic fertilizers. Fermented manure and Bokashi conserved higher soil levels of total N than the control ($P \leq 0.05$).

Compared with the control, the organic fertilizers maintained a higher soil content of available P. The vermicompost and fermented manure conserved high P levels in the soil of site 1 (58 and 43% higher than the control, respectively), Compared with the control at site 2, however, the fermented manure and Bokashi maintained higher levels of P in the soil and they increased the concentrations by 92 and 85%, respectively. Núñez (2007) suggested that organic fertilizers increased the availability of P because as the organic component decays it releases CO_2, and higher CO_2 concentrations would increase the decomposition rate of phosphate minerals and thereby increase the available P in the soil. These minerals synthesize phospho-humic complexes that are available to the plant and allow for the exchange of organic radicals by phosphates.

At both sites, all of the treatments increased K content in the soil (Tables 2 and 3). Ingelmo and Rubio (2007) suggested that K lixiviation is normal because K is a very mobile element in the soil; K provided by composts, sometimes higher than 85%, is an alternative to compensate for losses by leaching. At site 1, the highest K level in the soil was provided by the chemical fertilizer, followed by Bokashi and the vermicompost, with increases of 37, 31 and 24%, respectively, compared with the control ($P \leq 0.05$). At site 2, the highest K levels in the soil were provided by the fermented manure and compost with increases of 56 and 48% compared with the control ($P \leq 0.05$). Ochoa *et al.* (2009) used municipal organic residues and found significant increases in the P and K contents of volcanic soils. According to López (2012), the capacity of fermented manure, Bokashi, vermicompost and compost to supply nutrients to the soil occurs because they have the highest active mineralization rates.

N, P, K content in A. purpurata foliage

All of the treatments in site 1 had N, P and K values in the foliage that were higher than the lower limit acceptable for healthy and vigorous plants (Kent *et al*., 2007). The application of liquid humus significantly increased the amount of N in the foliage by 16% compared with the control at site 2 ($P \leq 0.05$). Arrigo *et al*. (2005) found a similar effect when they included residues from composted pruning on the N nutrition of ryegrass *Lolium perenne* L. Olivares-Campos *et al*. (2012)

Table 3. Organic carbon and nutrient contents in the soil with organic amendments 40 and 365 days after application in Ignacio Allende, Teapa, Tabasco, Mexico.

	Organic C		Total N		Available P		Exchangeable K	
	%				mg·kg-1		cmol kg-1	
Treat	40da	365da	40da	365da	40da	365da	40da	365da
T	2.40 d[1]	3.06 a	0.20 c	0.28 a	8.5 c	6.71 d	0.06 b	0.21 c
C	3.50 abc	3.16 a	0.31 a	0.26 ab	13.0 abc	12.90 cd	0.07 ab	0.41 ab
V	2.74 cd	2.80 a	0.30 ab	0.27 ab	10.5 bc	28.23 c	0.06 b	0.27 c
FM	3.06 bcd	2.97 a	0.22 c	0.28 a	13.5 abc	81.80 a	0.09 ab	0.48 a
B	4.02 a	3.14 a	0.23 bc	0.29 a	10.0 bc	43.61 b	0.08 b	0.27 c
LH	3.82 ab	2.80 a	0.31 a	0.25 ab	17.0 ab	8.80 b	0.07 ab	0.32 bc
Q	2.93 dc	2.78 a	0.27 abc	0.22 b	25.0 a	21.12 cd	0.1 a	0.34 bc

[1]Values followed by the same letter in the same column do not differ significantly (Duncan, P≤0.05) (n=3). Treat=treatments, T=control, C=compost, V=vermicompost, FM=fermented manure, B=Bokashi, LH=liquid humus, Q=chemical fertilizer, da=days after application.

obtained similar foliar N contents in lettuce *Lactuca sativa* L. when fertilized with compost, vermicompost or with inorganic N fertilizer.

The acceptable lower limit of the P content in foliage (0.16%), according to Kent *et al.* (2007), was surpassed at site 1. The highest P level in foliage was in the Bokashi application compared with the control at site 1 (P≤0.05), but at site 2, the treatments were similar for *A. purpurata* foliar P content.

Potassium levels in the foliage of the ginger plants at site 1 were significantly different among the treatments, with the highest concentrations found with Bokashi and liquid humus compared with the control (P≤0.05).

Production characteristics and flower quality

The increase in the production variables and in flower quality was significantly higher (P≤ 0.05) in *A. purpurata* when organic fertilizers were applied. Compost and fermented manure had higher numbers of stems (35.3%), amounts of commercial biomass (27.8%), amounts of noncommercial biomass (40.8%), amounts of total biomass (35.5%), longer stem length (19.2%), wider flower diameter (9.5%), longer flower length (12.3%) and wider stem diameter at 80 cm (16.0%) than the control, at both sites. Organic and chemical fertilizers increased production and quality levels equally (Tables 4 and 5). Similar results have been reported previously. For example, increased production was found when Cruz-Castillo *et al.* (2008) applied vermicompost to calla lily, *Zantedeschia aethiopica*, when Vázquez-Vázquez *et al.* (2011) applied sunned manure to chili, *Capsicum annuum*, and when Zaragoza-Lira *et al.* (2011) applied compost to pecan, *Carya illinoensis*. The chemical characteristics of the soil and the plant foliage were improved by the application of fermented manure, Bokashi and compost, as suggested by the positive correlations among organic C, soil macronutrients and the CEE. The chemical characteristics of the soil (C, NPK and CEE) led to a positive effect on the foliage nutrient content when fermented manure and compost were applied at site 1 (R=0.99; P≤0.0001). The same characteristics led to a positive effect on the foliage nutrient content when Bokashi and compost were applied at site 2 (R=0.99; P≤0.0001). However, only in the fermented manure and compost treatments were the foliar N, P, K contents positively correlated with the number of stems and the number of leaves at sites 1 and 2.

In summary, the application of organic fertilizers increased soil organic C (40%), total N (47%), available P (83%), and K (56%), and acceptable levels for production were maintained after one year. Fermented manure, vermicompost and compost have the capacity to supply macronutrients and are recommended for the localities used in this study.

Table 4. Effect of amendments on the yield of *A. purpurata,* 365 days after application in Medellín and Madero, Centro, Tabasco, Mexico.

		CB	NCB	TB	SL	FD	FL	SD
Treat.	NS	g			cm			
T	54 bc[1]	28.0 d	76.8 b	104.7 cd	185.8 c	7.6 c	25.0 bc	1.62 c
C	63 a	35.8 bc	95.8 a	131.8 a	213.0 ab	8.1 b	26.3 a	1.69 ab
V	54 bc	33.8 c	77.3 b	111.0 bc	198.5 bc	8.1 b	25.0 bc	1.62 c
FM	59 ab	38.8 a	102.0 a	140.5 a	216.8 a	8.4 a	26.3 a	1.71 a
B	49 c	33.3 c	65.5 c	99.0 d	191.0 c	8.0 b	24.8 c	1.61 c
LH	42 d	35.3 bc	83.7 b	118.3 b	201.0 abc	8.2 b	26.0 ab	1.66 bc
Q	58 ab	38.0 ab	98.0 a	136.0a	212.0 ab	8.4 a	26.3 a	1.73 a

[1]Values followed by the same letter in the same column do not differ significantly (Duncan, P≤0.05) (n=3). Treat=treatments, T=control, C=compost, V=vermicompost, FM=fermented manure, B=Bokashi, LH=liquid humus, Q=chemical fertilizer, da=days after application. NS=number of commercial stems per plant, CB=commercial biomass, NCB=noncommercial biomass, TB=total biomass, SL=stem length, FD=flower diameter, FL=flower length, SD=stem diameter.

Table 5. Effect of amendments on the yield of *A. purpurata,* 365 days after application in Ignacio Allende, Teapa, Tabasco, Mexico.

		CB	NCB	TB	SL	FD	FL	SD
Treat.	NS	g			cm			
T	11 b[1]	27.1 b	64.7 d	91.8 d	195.8 b	7.8 b	25.3 b	1.47 c
C	16 a	34.9 a	107.5 ab	142.4 a	241.9 a	8.4 a	28.8 a	1.75 a
V	14 ab	27.7 b	79.4 c	107.0 dc	218.1 ab	8.0 b	25.9 ab	1.62 b
FM	17 a	31.5 ab	109.4 a	140.9 ab	239.9 a	8.0 b	27.3 ab	1.75 a
B	17 a	35.1 a	90.1 c	125.2 ab	231.2 a	8.3 a	28.3 a	1.77 a
LH	16 a	29.6 b	110.7 a	140.3 ab	236.5 a	7.9 b	26.8 ab	1.70 ab
Q	13 ab	28.6 b	94.3 bc	125.9 bc	229.2 a	7.9 b	28.6 a	1.62 b

[1]Values followed by the same letter in the same column do not differ significantly (Duncan, P≤0.05) (n=3). Treat=treatments, T=control, C=compost, V=vermicompost, FM=fermented manure, B=Bokashi, LH=liquid humus, Q=chemical fertilizer, da=days after application. NS=number of commercial stems per plant, CB=commercial biomass, NCB=noncommercial biomass, TB=total biomass, SL=stem length, FD=flower diameter, FL=flower length, SD=stem diameter.

The N, P and K supplied by the amount of fertilizers used in this study was sufficient to satisfy the minimum requirements specified for *A. purpurata*. The fermented manure and compost may substitute for the chemical fertilizer for at least one year; therefore, they are a viable fertilization alternative to reach optimal levels of production and quality without contaminating the environment.

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Resumen

M.I. Saldaña y Hernández, R. Gómez-Álvarez, M. del C. Rivera-Cruz, J.D. Álvarez-Solís, J.M. Pat-Fernández y C.F. Ortiz-García. 2014. Influencia de abonos orgánicos en las propiedades químicas del suelo y producción de *Alpinia purpurata*. Cien. Inv. Agr. 41(2):215-224. Los abonos orgánicos aportan cantidades importantes de materia orgánica que modifica las características físicas, químicas y microbiológicas del suelo. Para conocer el impacto de los abonos sólidos y líquidos en *A. purpurata*, se evaluaron las principales características químicas del suelo y la respuesta de la planta a 40 y 365 días en Medellín y

Madero e Ignacio Allende, Tabasco, México. Los tratamientos evaluados fueron Composta, Vermicomposta, Estiércol Fermentado, Bocashi y Humus líquido (6 $Mg·ha^{-1}$ y 60 $L·ha^{-1}$), Fertilizante Químico (150-50-250) y un Testigo absoluto, bajo un diseño experimental de bloques completos al azar, con tres repeticiones. La unidad experimental fue una cepa. Del suelo se determinó: concentración de C orgánico, N total, P disponible y K intercambiable; en follaje: N, P y K; por cepa: número de tallos y biomasa comercial y no comercial; por tallo: longitud y diámetro; diámetro y longitud de la flor. Los suelos abonados mostraron a los 40 días incrementos de C (40%), N (47%), P (83%) y K (56%), un año después de adicionados los abonos los suelos mantuvieron niveles aceptables de fertilidad para la producción. El Bocashi aumentó la concentración de P (9,5%) y K (8,3%) en el follaje de las plantas en Medellín y Madero. El Humus Líquido aumentó el N foliar (16%) en Ignacio Allende. Las plantas abonadas con Estiércol Fermentado y Composta mejoraron la producción de número de tallos (35,3%), biomasa total (35,5%), longitud de tallo (19,2%), diámetro del tallo (16%), diámetro de la flor (9,5%), longitud de la flor (12,3%).

Palabras clave: Bocashi, composta, estiércol fermentado, ginger rojo, macronutrientes, vermicomposta.

References

Arreola, M.A., J. Sánchez, A. Vargas and L. Hernández. 2011. Ordenamiento territorial: Microrregión Sierra de Tabasco. Secretaría de Recursos Naturales y Protección Ambiental e Instituto para el Desarrollo Sustentable en Mesoamérica A.C., Petróleos Mexicanos. Villahermosa, Tabasco, México. 125 pp.

Arrigo, N.M., M.P. Jiménez, R.M. Palma, M. Benito, and M.F. Tortarolo. 2005. Residuos de poda compostados y sin compostar: Uso potencial como enmienda orgánica en suelo. Ciencia del Suelo 23:253-265.

Baltazar, B.O. and K.A. Figueroa. 2009. Flores que atrapan tu mirada. Estudio de vida de florero y comercial de flores ornamentales de la Zona Centro del Estado de Veracruz. Colegio de Postgraduados. México. 80 pp.

Cruz-Castillo, J.G., P.A. Torres-Lima, M. Alfaro-Chilmalhua, M.L. Albores-González, and J. Murguía-González. 2008. Lombricompostas y apertura de la espata en poscosecha del alcatraz “Green Goddess”, *Zantedeschia aethiopica* (L.) K. Spreng, en condiciones tropicales. Revista Chapingo, Serie horticultura 14:207-212.

DOF–Diario Oficial de la Federación. 2002. NOM-021-RECNAT-2000 Norma Oficial Mexicana que establece las especificaciones de fertilidad, salinidad y clasificación de suelos. Estudios, muestreos y análisis. SEMARNAT. México, D.F. 85 pp.

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z. Kawabata, D. Knowler, C. Lévêque, R.J. Naiman, A-H APrieur-Richard, D. Soto, M.L.J. Stiassny, and C.A. Sullivan. 2006. Freshwater biodiversity: importance, status and conservation challenges. Biological Reviews of the Cambridge Philosophical Society 81:163-182.

Evanylo, G., C. Sheron, J. Spargo, D. Starner, M. Brosius, and K. Haering. 2008. Soil and water environmental effects of fertilizer manure, and compost-based fertility practices in an organic vegetable cropping system. Agriculture, Ecosystems and Environment 127:50-58.

Gosling, P., A. Hodge, G. Goodlass, and G.D. Bending. 2006. Arbuscular mycorrhizal fungi and organic farming. Agriculture, Ecosystems and Environment 113:17-35.

Ingelmo, S.F., and J.L Rubio. 2007. Efecto de la aplicación del compost sobre las propiedades físicas y químicas del suelo. *In*: Moreno, C.J., and H.R. Moral (Eds.). Compostaje. Ed. Mundi-prensa. Madrid. p. 307-330.

INEGI. 2001. Síntesis de información geográfica del estado de Tabasco. Instituto Nacional de

Estadística, Geografía e Informática (INEGI). Aguascalientes, México. 89 pp.

Kent, D.K., J. McEwen, and A.J. Kaufman. 2007. Ornamental Ginger, Red and Pink. Ornamentals and Flowers. University of Hawai´I at Mãnoa, College of Tropical Agriculture and Human Resources. UH-CTAHR.OF-37:1-8.

López, R.Y. 2012. Efecto de diferentes abonos orgánicos en la producción de *Alpinia purpurata* (Vieill.) K. Schum en Tabasco, México. Tesis de Maestría. El Colegio de la Frontera Sur. 75 pp.

Núñez, E.R. 2007. El suelo como medio natural en la nutrición de los cultivos. *In*: Alcántar, G.G. and Trejo-Téllez, L.I. (coord.). Nutrición de cultivos. Mundi Prensa. Colegio de Postgraduados, México. p. 94-157.

Ochoa, E.S., C.A. Ortiz, Ma. del C., Gutiérrez, R. Quintero, and T.J. Silva. 2009. Aplicación directa de residuos sólidos orgánicos municipales a suelos volcánicos. Terra Latinoamericana 27:53-62.

Olivares-Campos, M.A., A. Hernández-Rodríguez, C. Vences-Contreras, J.L. Jáquez-Balderrama, and D. Ojeda-Barrios. 2012. Lombricomposta y composta de estiércol de ganado vacuno lechero como fertilizantes y mejoradores del suelo. Universidad y Ciencia 28:27-37.

Rivera-Cruz, M.C., A. Trujillo-Narcia, and D.E. Alejo. 2010. Los biofertilizantes integrados con bacterias fiadoras de N, solubilizadoras de P y sustratos orgánicos en el crecimiento de naranjo agrio *Citrus aurantium* L. Interciencia 35:113-119.

Rodríguez, D.N., R.P. Cano, V.U. Figueroa, C.E. Favela, R.A. Moreno, H.C. Márquez, M.E. Ochoa, and R. Preciado. 2009. Uso de abonos orgánicos en la producción de tomate en invernadero. Terra Latinoamericana 27:319-327.

Saldaña, H.M.I., R. Gómez, J.M. Pat, J.D. Álvarez, J. Pérez, and C.F. Ortiz. 2013. The socioeconomic and technical status of cut flower producers in Tabasco, Mexico. Ciencia e Investigación Agraria 40:397-410.

Sikora, L.J., and N.K. Enkiri. 2001. Uptake of 15N fertilizer in compost-amended soils. Plant and Soil 235:65-73.

Texeira, M.C.F. and V. Loges. 2008. *Alpinia*: Cultivo e comercializacao. Revista Brasileira de Horticultura Ornamental 14:9-14.

Vargas, G.M.C., and F. Suárez. 2007. Efecto de la aplicación del compost sobre las propiedades biológicas del suelo. *In*: Moreno C.J. and Moral H.R. (eds.). Compostaje. Ed. Mundi-prensa. Madrid. p. 329-350.

Vázquez-Vázquez, C., J.L. García-Hernández, E. Salazar-Sosa, J.D. López-Martínez, R.D. Valdez-Cepeda, I. Orona-Castillo, M.A. Gallegos-Robles, and P. Preciado-Rangel. 2011. Aplicación de estiércol solarizado al suelo y la producción de chile Jalapeño (*Capsicum annuum* L.). Revista Chapingo. Serie Horticultura 17:69-74.

Wu, S.C., Z.H. Cao, Z.G. Li, M.K.C. Cheung, and W.H. Wong. 2005. Effects of biofertilizer containing N fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Geoderma 125:155-166.

Zaragoza-Lira, M.M., P. Preciado-Rangel, U. Figueroa-Viramontes, J.L. García-Hernández, M. Fortis-Hernández, M.A. Segura-Castruita, and A. Lagarda-Murrieta. 2011. Aplicación de composta en la producción de nogal pecanero. Revista Chapingo. Serie Horticultura 7:33-37.

Zúñiga-Estrada, L., J.J. Martínez-Hernández, G.A. Baca-Castillo, A. Martínez-Garza, J.L. Tirado-Torres, J. Kohashi-Shibata, and J. Cruz-Díaz. 2010. Efecto de la fertilización con potasio en un vertisol sobre la relación cantidad/intensidad (Q/I). Terra Latinoamericana 28:319-325.