



Supply Chain to Industrialization of Pig Excrete by Biotransformation to Increase Corn Performance

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Abstract: The objective of this work is evaluate manure of Mexican Hairless Pig (MHP) from the three energy levels: high 3.5, medium 2.5 and under 1.5 of metabolizable energy for maintenance (MEM) kg body weight⁻¹ processed as fertilizer in shape in dry, mature and fresh for corn yield. In this work was established a design completely randomized with factorial arrangement 3 x 3 with 3 replications. The excreta of pigs fed with medium and low levels promoted ($p \leq 0.05$ y $p < 0.01$) higher content of forage in dry matter (DM) and excreta from high levels increased ($p \leq 0.05$ y $p < 0.01$) the content of nitrogen retained in the plant. The manure dry and mature increased 12.5% diameter and 15% leaf area in corn plants, with respect to fresh excreta. The dry manure promoted 6.1% the number of leafs with respect to mature and fresh excreta. The manure dry and mature increased 21.2% content DM in plant, 18.8% cob, and 26% grain with respect to fresh excreta. The dry excrete high level, excelled in most of the variables evaluated, followed by excrete dry from the medium and excrete mature from the level medium and lower.

Keywords: Organic Fertilizers, Sustainability, Corn Production, Corn Supply Chain

1. Introduction

The processing methods to produce fertilizer from excreta are diverse, to be main the composting, microbial process that converts organic waste materials into a product of agricultural interest [14], another method is to dry gradually excreta to remove moisture facilitating handling this [3] and the implementation of activities of grazing pigs, being an appropriate and sustainable form of land use [1]. Such methods provide a management system for optimizing animal waste and crop production contributing to an integrated management of recycling nutrients to the soil.

However, during processing the excreted lost nutrients due among other things to handling food animal that affect the characteristics excreta; It is known about pigs fed with forage in their diet have changes in the characteristics and nitrogen partition in excreta [7] and [13].

In this sense the Mexican hairless pig (MHP) show a lower nitrogen retention when feed with low protein and low energy densities in the food, which requires complete feeding forage [18], which It ensures a diet that generate less manure nitrogen losses during processing as fertilizer and greater contribution to the requirements of the plant.

The aim of this study was to evaluate manure of Mexican hairless Pig (MHP) from three energy levels: high 3.5, medium 2.5 and under 1.5 metabolizable energy for maintenance (MEM) kilogram weight live⁻¹ processed as manure in form dry (without maturation) mature (subject to a composting process) and fresh (defecated during the stay of pigs on pasture) on corn yield.

2. Materials and Methods

2.1. Experimental Area

This work was done from June 30 to October 27, 2011 (120 days) under reed conditions on the campus of Biological and Agricultural Sciences located in the downtown area of Yucatán at 21°06 'N latitude and 89°27'W longitude, to an altitude of 8 msnm. The climate is tropical humid with summer rains, according to the Köppen classification, modified by [12]. The annual average temperature is 25.8°C with relative humidity of 75-80% and average rainfall of 984.4 mm annually accumulating 81% during the months of May to October [3]. See Figure 1.



Figure 1. Place where the experiment was conducted.

2.2. Origin of Organic Material

The excreted dry and mature was obtained from Mexican hairless Pigs (MHP) stabled in individual pens and divided into 3 energy levels: high 3.5, medium 2.5 and under 1.5 metabolizable energy for maintenance (MEM) kg live weight⁻¹; while fresh excreted was incorporate by nine pigs in Luvisol floor, divided into 3 plots with a different level of energy (high, medium and low), each pig stay in a corral. The experiment occupied an area of 2,160 m². See Figure 2.



Figure 2. Mexican hairless pig.

2.3. Excreted Dry (Without Maturation)



Figure 3. Dry excreted.

Excreta were collected individually by animal and empty in aluminum trays that stay under shadow 3-5 days to remove moisture, then they were stored in paper bags labeled with the number of repetition and belonging MEM level. See Figure 3.

2.4. Mature Excreted (Compost)

A portion of the dry excreta collected from each pig matured through composting, in individual concrete containers 1.50 m long x 0.90 m wide and 0.5 m high covered with wood top. Excreta were removed twice weekly until the temperature showed no change (seven weeks). Finally they were kept in paper bags labeled with the number of repetition and belonging MEM level. See Figure 4.



Figure 4. Composting.

2.5. Fresh Excreta (Defecate for Pigs While in Grazing)

9 pigs were used, 33 kilos. Food distributed in three levels: high 3.5, medium 2.5 and under 1.5 kg weight live⁻¹ MEM present in the parcels, with 3 pigs per level. Each individually Remained pig in a pen of 6 x 10 m made of welded mesh of 5 mm, a trough of metal and a shelter for 40 days. See Figure 5.



Figure 5. Mexican hairless pigs grazing.

2.6. Transplant and Plant Fertilization

In each plot were transplant 180 maize plants with a spacing of 0.6 m between rows and 0.5 m between plants (30,000 plants ha⁻¹). During the transplant were done a hole 20cm in the ground, where it was deposited and rolled a ratio of 100 g of excreta (1 g N plant⁻¹) equivalent to 30 kg N ha⁻¹ immediately placing a seed corn, the same was made dose of nitrogen was applied as fresh excreted by pigs being defecated while in the plots.

2.7. Variables Assessed

One day after transplant were randomly selected and labeled 15 corn plants. At the end of the crop (120 days) the following variables were measured: plant height (cm), stem diameter (cm) The number of leaves and leaf area of the leaf (cm^2) was estimated by the equation: (length leaf) \times AH (sheet width) \times 0.75 (correction factor) [2] and [4] plant performance, fodder, corn and grain (Ton MS ha^{-1}) and total nitrogen content retained in plant (Kg N plant^{-1}).

2.8. Experimental Design

Corn plants are distributed in a completely randomized design 3×3 factorial arrangement with 3 replications. Factor 1, corresponded to three energy levels: high 3.5, medium 2.5 and under 1.5 (MEM) kg body weight live $^{-1}$ and factor 2, the processing of excreta: dry, mature and fresh. The data obtained were analyzed using the SAS statistical software version 9.0 and comparison of means was performed using the Tukey test ($p < 0.05$ y $p < 0.01$).

3. Results and Discussion

3.1. Corn Plants

The excreta of pigs fed with high levels 3.5 and 2.5 medium of metabolizable energy for maintenance (MEM) kgweight live $^{-1}$ increased ($p \leq 0.05$ y $p \leq 0.01$) the height of corn plants, respect to the level under 1.5 EMM kg $^{-1}$ live weight with 7.72% difference compared to high and similar to medium level. Dry and mature increased 12.5% diameter and 15% leaf area respect to fresh excreta. The dry excreta increased 6.1% the number of leaf respect to mature and fresh excreta. As for the interaction of levels MEM kg body weight live $^{-1}$ and the excreted processing, the excrete dry of high level excelled ($p \leq 0.05$ y $p \leq 0.01$) in all variables measured during maize growth, results they are seen in table 1.

The disposition of excreta nutrients used as manure during growing maize [9] and [8] has been successful, which it was checked using dry excrete of high level, reporting a plant height similar to found by [16] applying 5 to 10 g N plant $^{-1}$ dry cattle manure in forage corn with an average height of 262.5 cm. Similar results were obtained with the mature excreted high level and fresh excreted from the low level to that reported by [11] to apply for 3 years (2001, 2002 and 2003) the average amount of 74.3 t ha $^{-1}$ (220 kg N ha $^{-1}$) dry cow dung to 15,200 plants ha $^{-1}$ in forage maize (hybrid SB-302) with height of 228 cm on the ground. apply for three years (2009, 2010 and 2011) consecutive 0.7 g N plant $^{-1}$ (ammonium nitrate) equivalent to 70 kg N ha $^{-1}$ corn (variety Anjou 387) to 95,000 plants ha $^{-1}$ with heights of 214.5 cm and 263 cm 2 leaf area apply for three years (2009, 2010 and 2011) consecutive 0.7 g N plant $^{-1}$ (ammonium nitrate) equivalent to 70 kg N ha $^{-1}$ corn (variety Anjou 387) to 95,000 plants ha $^{-1}$ with heights of 214.5 cm and 263 cm 2 leaf area. apply for three years (2009, 2010 and 2011) consecutive 0.7 g N plant $^{-1}$ (ammonium nitrate) equivalent to 70 kg N ha $^{-1}$ corn (variety Anjou 387).

In this paper were obtained results higher height and leaf area as reported by [17] by applying 5 to 10 g N plant $^{-1}$ dry cattle manure in forage maize with 210 cm height and leaf area of 76.02 cm 2 respectively [4].

Table 1. Variables measured in corn used as manure excreta processed manure dry, mature and fresh.

Treatment	Height (cm)	Diameter (cm)	Leaf area (cm 2)	Number of leaves
Excrete	ns	**	**	**
Dry	252	1.45 ^a	500 ^a	13.9 ^a
Mature	251	1.43 ^a	503 ^a	12.9 ^b
Fresh	241	1.26 ^b	426 ^b	13.2 ^b
EEM	6.99	0.02	12.1	0.17
Level	**	Ns	Ns	ns
High	259 ^a	1.39	481	13.5
Medium	247 ^{ab}	1.38	478	13.4
Low	239 ^b	1.36	470	13.1
Interaction (N \times E)	**	**	*	ns

Means within a row followed by different letters are significantly different (Tukey test) ns: not significant * $p < 0.05$; ** $p < 0.01$.

3.2. Dry Matter and Yield to Plant, Corn, Grain and Forage

The excreta of pigs fed with levels medium and low (2.5 and 1.5 kg weight live $^{-1}$ (MEM) increased ($p \leq 0.05$ y $p \leq 0.01$) the content of forage with difference of 21% compared to the high level. The excrete dry and mature ($p \leq 0.05$) increased 21.2% in (DM) plan, 18.8% cob and 26% grain respect to fresh excreta. In interaction of levels MEM kg body weight $^{-1}$ and the processing excrete, the mature excreted from the level middle and mature excreted from the low level, increased the DM content, followed by dry excreted from the high level dry excreted from the middle level; in contrast, the lowest results were obtained with the use of dried excreta of low level, high level excreted mature and fresh excreta of three energy levels. The results are shown in Table 2.

Table 2. Performance of plant, fodder, corn and grain corn used as manure excrete processed dry, mature and fresh.

Treatment	Plant	Fodder	Cob	Grain
	(Ton DM ha $^{-1}$)			
Excreta	**	**	**	**
Dry	5.11 ^a	0.72 ^b	3.34 ^a	1.03 ^a
Mature	5.25 ^a	0.82 ^a	3.45 ^a	0.97 ^a
Fresh	4.08 ^b	0.58 ^c	2.75 ^b	0.74 ^b
EEM	0.19	0.02	0.16	0.06
Level	ns	**	ns	**
High	4.59	0.60 ^b	3.11	0.87 ^{ab}
Medium	4.98	0.72 ^a	3.21	1.04 ^a
Low	4.86	0.80 ^a	3.23	0.83 ^b
Interaction (N \times E)	**	**	**	**

Means within a row followed by different letters are significantly different (Tukey test) ns: not significant * $p < 0.05$; ** $p < 0.01$.

A high number of plants ha $^{-1}$ does not mean a higher content of DM however, the DM can change its distribution in plant organs as reported [10] who indicate that population density has a signification effect on the distribution of DM in the vegetative and reproductive areas of the plant. [6] to study

three doses of nitrogen fertilization (125, 250 and 375 kg N ha⁻¹) and 5 densities on forage maize they found that more than 9 plants / m² densities did not significantly increase the performance of DM in plant. In this paper superior results were obtained in MS floor, while on the cob and forage low production yield, in contrast to the findings by [4] to apply were reported 0.7 g N plant⁻¹ (70 kg N ha⁻¹) in corn (variety Anjou 387) for three consecutive years, to 95,000 plants ha⁻¹ reporting a DM content in plant, ear and forage 3.1, 4.7 and 2.6 ton DM ha⁻¹, respectively; while, [15] to determine the production and quality of forage with 180 and 240 kg N ha⁻¹ and three densities: 60,000, 80,000 and 100,000 plants ha⁻¹ hybrid corn (H-376 and Lobo) concluded that the best dose was 240-90-00 (N-P₂O₅-K₂O) increasing from 1.3 to 3.3 ton DM ha⁻¹ fodder by increasing planting density 60 000 to 100 000 plants ha⁻¹ with the H-376 variety. Different results forage yield were obtained as reported by [20] to apply on average over three years the amount of 74.3 t ha⁻¹ (220 kg N ha⁻¹) of dry cattle manure to 15,200 plants ha⁻¹ corn (hybrid SB-302) obtained 18.5 ton DM ha⁻¹ fodder. For his part [11] evaluated the effect of the application of organic fertilizers (Biocompost and vermicompost) in forage production of a hybrid yellow corn determined that the best performance corresponded to vermicompost con 13 Ton DM ha⁻¹. In this paper 100 g apply excreted plant⁻¹ (30 kg N ha⁻¹) in corn (variety Nal-xoy) where similar results were obtained on the cob with the use of dried excreta of intermediate and mature excreted level average (3.20 and 3.73 t DM ha⁻¹); It is different in forage and grain as reported by [15] using 360 g of excreta and veal (7.8 g N plant⁻¹) equivalent to 5 t ha⁻¹ (109.5 kg N) in native maize race Oloton temporarily to 13,889 plants ha⁻¹ with forage yield, cob and grain: 4.56, 3.29 and 2.62 t DM ha⁻¹ respectively. [1] to apply 600 g of compost (9 g N plant⁻¹) equivalent to 6 t ha⁻¹ (90 kg N ha⁻¹) in corn to 10,000 plants ha⁻¹ recorded a yield of 2.7 t ha⁻¹ grain and [14] to apply 20, 30 and 40 ton ha⁻¹ of dry cattle manure in maize genotype San Lorenzo obtained yields of 2.63, 5.60 and 4.81 respectively Ton MS grain.

3.3. Total Nitrogen Retained in the Plant

Table 3. Content of total N retained at the end of the crop plant used as manure excreted processed dry, mature and fresh.

Treatment	Total nitrogen retained (Kg N plant ⁻¹)
Excrete	**
Dry	0.18 ^b
Mature	0.17 ^b
Fresh	0.25 ^a
EEM	0.01
Level	**
High	0.23 ^a
Medium	0.19 ^b
Low	0.18 ^b
Interaction (N x E)	**

Means within a row followed by different letters are significantly different (Tukey test) ns: not significant * p < 0.05; ** p < 0.01.

The excreta of pigs fed high levels EMM 3.5 kg live⁻¹ increased (p ≤ 0.05) 19.5% N content in ground held regarding

pig excreta of lower and middle level MEM kg live⁻¹. Using fresh excreta as fertilizer increased (p ≤ 0.05) 30% N plant, relative to dry and mature excreted. As for the interaction of levels MEM and excreted processing, dry manure favored the high level (p ≤ 0.05 y p ≤ 0.01) total N content in plant⁻¹, being similar to using fresh excreted from the middle level, fresh excreta the low level and high level of dry excreta; in contrast with the lower results obtained with the use of dry excreta low level. See Table 3.

It is assumed that the fresh excreta, incorporated into the soil while in pigs grazing, initially presented a temporary immobilization of N as pointed out by [17] with the pattern of mineralization found in pig feces to start a phase of immobilization and after 6 weeks net mineralization. However, during maize growth increased availability to the plant is presumed, consistent with those reported by [19] in a study of forage sorghum (*Sorghum vulgare*) with different amounts composting considering that one of the risks of adding amendments is to cause temporary immobilization of N depending on organic content, thus limiting the availability of this nutrient for growing and restricting the initial growth in the plant.

Higher than that reported by [15] to apply for 3 years an average of 74.3 ton values were ha⁻¹ (220 kg N ha⁻¹) of cattle manure to 15,200 plants ha⁻¹ corn (hybrid SB-302) obtained 0.012 kg N retained in plant⁻¹ at the end of cultivation and [5] using different amounts of zeolite and fertilizer (200 kg N ha⁻¹) in corn determining that the end of culture was retained 0.03 kg N plant⁻¹.

4. Conclusions

The dried manure pigs fed with high levels of maintenance metabolizable energy per kilogram live weight (3.5 MEM kg live weight⁻¹) as fertilizer favored the diameter, leaf area and number of leaves on corn; followed by mature manure the average level (2.5 kg MEM weigh live t⁻¹) and the low level of fresh manure (1.5 kg MEM weight live t⁻¹). Likewise, the average level of mature manure increases dry matter content in plant, ear and grain; followed by dry excreta high level and low level fresh excreta. The application of fresh manure promoted a high level of higher nitrogen content in maize plants, with respect to dried excreta of low and medium level of mature manure.

References

- [1] Álvarez R. C., Torres D.M. Chamorro E.R. Ambrosio M.A. 2009. Descompactación de suelos franco limosos en siembra directa: efectos sobre las propiedades edáficas y los cultivos. Facultad de agronomía de la universidad de buenos aires argentina. CI. Suelo (Argentina) 27(2): 159-169.
- [2] Avendaño A.C., Molina, J.D., Trejo C.C., López C. y Cadena. I. J. 2008. Respuesta a altos niveles de estrés hídrico en maíz. Agronomía Mesoamericana 19(1): 27-37.
- [3] Bautista F., Palma L. D. y Huchin M. W. 2005. Actualización de la clasificación de los suelos del estado de Yucatán. 105- 122.

- [4] Bolaños A. E. y Jean C. E. 2012. Distancia entre surcos en el rendimiento y calidad de la materia seca de maíz. *Revista Mexicana de Ciencias Pecuarias*. 2(3):299-312.
- [5] Civeira, G. y Rodríguez. M. B. 2011. Nitrógeno residual y lixiviado del fertilizante en el sistema suelo-planta-zeolitas. *CI. Suelo (Argentina)* 29(2): 285-294.
- [6] Cueto W.J., Reta D.S.G., Barrientos R.J.L. Gonzales C.G. y Salazar. S.E. 2006. Rendimiento de maíz forrajero en respuesta a la fertilización nitrogenada y densidades de población. *Revista Fitotecnia Mexicana*. 29 (97) 101.
- [7] Delve R.J., Cadish G., Tanner J.C., Thorpe W., Thorne P.J. y Giller. K.E. 2000. Implications of livestock feeding managements on soil fertility in the smallholder farming systems of sub-Sahara Africa. *Agricultural Ecosystem Environment* 84: 227-243.
- [8] Del pino A.C., Repetto C.A. y Mori C.P. 2008. Patrones de descomposición de estiércoles en el suelo. *Terra latinoamericana* 26: 43-52.
- [9] Eghball B. J., Wienhold J. E. Gilley J. E. y Eigenberg R.A. 2002. Mineralization of manure nutrients. *J. Soil Water Conserv.* 57: 470-473.
- [10] Fallah S. y Tadayyon. A. 2010. Absorción y eficiencia del nitrógeno en maíz forrajero: efecto del nitrógeno y la densidad de población. *Agrociencia*. 44: 549-560.
- [11] Fortis H. M., Leos R.J.A., Preciado R.A., Orona C.I. García, S.J.A., García H.J.L. y Orozco V.J.A. 2009. Aplicación de abonos orgánicos en la producción de maíz forrajero con riego por goteo. *Terra latinoamericana*. 27 (4): 329-336.
- [12] García E. 1988. Modificaciones al sistema de clasificación de Köppen. México, D.F.
- [13] Gerard L., Velthof J., Nelemans O. y Kuikman. P. 2005. Gaseous nitrogen and carbon losses from pig manure derived from different diets. *Waste Management. Technical reports. Journal Environment Quality*. 34: 698-706.
- [14] López M.J.D., Díaz A.E. Martínez E. R. y Valdez C. 2001. Abonos orgánicos y su efecto en propiedades físicas y químicas del suelo y rendimiento en maíz. *Universidad Autónoma de Chapingo. Terra Latinoamericana*. 19(4):293-299.
- [15] Peña R.A., González C.F. y Robles. E.F. 2010. Manejo agronómico para incrementar el rendimiento de grano y forraje en híbridos tardíos de maíz. *Revista Mexicana de Ciencias Agrícolas* 1 (1).
- [16] Salazar S. E., Trejo, E. H., Vázquez, I. V.C. López M.J. Fortis H.M., Zuñiga T.R. y Amado A.J. 2009. Distribución de nitrógeno disponible en suelo abonado con estiércol bovino en maíz forrajero, *Terra Latinoamericana* 27 (4): 373-382.
- [17] Salazar S.E., Trejo E.H., Lopez M.J., Vazquez V.C., Serrato C.S., Orona C.I. y Flores M.J.P. 2010. Efecto residual de estiércol bovino sobre el rendimiento de maíz forrajero y propiedades del suelo. *Terra Latinoamericana*. Vol.28, (4):381-390.
- [18] Trejo L.W. 2005. Strategies to improve the use of limited nutrient resources in pig production in the tropics, supplement 85. *unikassellersitat. Journal of agriculture and rural developmen in the tropics and subtropics*. 37- 38.
- [19] Wing C.R., Rojas A. y Quan. A. 2005. Nitrógeno orgánico y químico en sorgo negro con cobertura permanente de maní forrajero. *Características nutritivas y de reproducción. Agronomía Costarricense*. 29(1): 29-39.