YIELD AND CHEMICAL COMPOSITION OF *Manihot esculenta* Crantz FLOUR WITH ORGANIC FERTILIZATION IN QUINTANA ROO, MEXICO

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Abstract: The objective of this study was to evaluate the production and nutritional composition of cassava (*Manihot esculenta* Crantz) cultivated under different levels of organic fertilizer application. Twenty cassava plots (10 × 10 m) were established on the field and fertilizer treatments were applied at 0.0, 0.5, 1.0 and 1.5 kg plant^{-1} of filter cake compost of sugarcane (*Saccharum officinarum* L.). The cassava tubers were harvested, weighed, washed, dried and pulverized for nutritional composition determination. The variables measured were dry tuber yield, meal yield, and chemical composition. Organic fertilization application increased tuber yield 2-3 times when compared to the control. The application of 1.5 kg plant^{-1} organic fertilizer improved the crude protein content by 48% relative to the control. However, the content of neutral detergent fiber, organic matter and ash were similar among the treatments. It is concluded that organic fertilizer improved tuber yield and flour. Increase in crude protein content with the application of 1.5 kg plant^{-1} filter cake compost was also observed.

Keywords: Cassava, compost, filter cake, organic fertilizer, nutritional value, tuber

Introduction

Feed has been reported to be one of the most important factors in the meat production industry, since it accounts for more than 80% of the total production costs (Duarte and Pelcastre, 1998). In south-eastern Mexico, livestock production is impacted due to lack of inputs produced in the region that can be used to feed ruminants and available alternatives are either of poor quality or expensive. Hence, such practices have negative impacts on the production parameters and profitability of livestock production (Chay-Canul *et al.*, 2009). The development of supplements for ruminants is based on the use of cereal grains such as corn and sorghum, constituting 40-60% of the inputs used. This causes marked competition between human and animal feed in the local thereby market which results in increase in production cost. The high demand for grains has increased the use of food supplements in feed production systems and limiting the development of tropical livestock.

Therefore, it is necessary to obtain and manage new inputs in ruminant feed that can be easily generated by producers keeping the production cost under control (Chay-Canul *et al.*, 2009). In this regard, cassava (*Manihot esculenta* Crantz) is a tropical tuber that has received little attention in Mexico as a potential substitute for cereals in ruminant feed (Duarte and Pelcastre, 1998). Cassava can be cultivated both for tuber production as well as foliage for animal feed. The root yield per cassava plant varies between 1-3 kg; and up to 5-10 kg plant^{-1} can be achieved under optimal conditions of the tropical and sub-tropical regions (Aristizábal and Sánchez, 2007). It is drought resistant, tolerant to poor soil with easy agronomic management practices under tropical and sub-tropical climatic regimes; demonstrate high yield in roots and forage; and can be easily converted into whole meal (Marcano *et al.*, 1998).

In Mexico, cassava is mostly planted in the states of Tabasco and Michoacán. The national production averages are 14 t ha^{-1} in the temporal region and 32 t ha^{-1} under irrigation (Gil and Buitrago, 2002). The characteristics of this crop allow the use of leaves and tuber to produce flours (Duarte and Pelcastre, 1998). Since it is easy to harvest the forage, it is also the cheapest source of starch (Marcano *et al.*, 1998). However, when fertilizer is applied to cassava, excess nitrogen in the crop reduces the starch content and increases the protein content of the roots, which influences the production of whole cassava meal for animal feed; hence, use of organic fertilizers have been suggested to avoid this problem (Aristizábal and Sánchez, 2007). There is ample evidence that crops grown in soils rich in organic matter such as soils fertilized with sugarcane (*Saccharum officinarum* L.) filter cake compost (or in other words, residues of impurities filtered from clarified juice of sugarcane used as fertlizer) are biologically active; and are less susceptible to pest attacks, favors bioavailability and biosorption of essential nutrients, increase biomass and yield (Gordillo *et al.*, 2011). Although, there is high potential for the use of organic fertilizers in cassava crop production, its cultivation and use in ruminant feeding in southeastern Mexico is almost negligible. Therefore, the present work evaluated the effect of different levels of organic fertilization with filter cake compost of sugarcane on the yield of forage, tuber production and nutritional composition of cassava flour in Quintana Roo, Mexico.

Material and Methods

Site of study

The study was carried out at the geographical coordinates 21°51'N 89°41'W, with a warm sub-humid climate type Aw1, (humid warm with rains in summer and part of winter). The average annual temperature fluctuates between 24.5 and 25.8°C. It is almost at sea level and its topography is flat. The predominant soils are of the gleysol type according to the FAO classification (WRB, 2007).

Experimental plots

The area was prepared by means of a sub-soiler step, followed by a heavy dredge pass and two crossed light dredge passes. Likewise, the land was furrowed by means of the cultivator's pass at a distance of 1 m between the lines and later the parcels were delimited to assign the treatments and repetitions. The area was established at the beginning of June 2014, using vegetative material of *M. esculenta*, which were cut 150 days post establishment. The rods were cut into fragments of 40 cm and 24 h later were planted vertically at a distance of 1 m between furrows and between plants to obtain a density of 10,000 plants ha^{-1}. For the distribution of the crop, a total of 20 completely randomized plots (10 × 10 m) were established with a separation of 1 m between plots in order to avoid the edge effect between treatments. At 15 and 45 days post sowing; organic fertilization with filter cake compost of sugarcane was manually applied with the following rates: 0.0, 0.5, 1.0 and 1.5 kg plant^{-1}. Each treatment had 5 replicates.

Response variables

The yield of tuber was determined by manual harvesting 180 days post sowing, pocketed and weighed fresh with a platform scale with 120 kg capacity. Subsequently, a sample of 5 kg was taken per treatment and repeated and dried in a forced air circulation oven at 60°C for 72 h to determine the dry matter content. To prepare the flour, 20 kg of fresh tuber were used per treatment, washed, chopped into slices (2 cm thick), dried in a forced air oven at 60^{o}C for 72 h and pulverized with the help of a Hammer mill with a 3 mm screen. The contents of crude protein, neutral detergent fiber, organic matter and ashes of cassava flour were determined by AOAC (1990) protocols.

Statistical analysis

The variables evaluated were subjected to a one-way analysis of variance according to PROC GLM (SAS, 2010). When differences were found, a Duncan mean comparison test (P <0.05) was performed with the SAS statistical package 9.2 for Windows (SAS, 2010).

Results & Discussion

Organic Application of fertilizer based on filter cake improved from two to almost three times the yield of tuber and meal compared to the control (without fertilizer), and with fertilization levels of 0.5 and 1.5 kg plant^{-1} being the best production values obtained (Table 1). The crude protein content of the cassava flour was increased (48%) on application of organic fertilizers at 1.5 kg of plant^{-1} when compared to the control. However, the contents of neutral detergent fiber, organic matter and ash were similar among the treatments (Table 2).

Table 1: Yield of tubers and cassava (*Manihot esculenta*) flour under different levels of organic fertilization in gleysol soil

Parameter (t MS ha^{-1})	Organic fertilization (kg plant^{-1}) 0.0	0.5	1.0	1.5	SEM	Sig.
Tuberyield	1.4 b	4.1 a	3.2 a	4.2 a	0.7	*
Flouryield	1.3 b	3.5 a	3.2 a	4.1 a	0.8	*

S.E.M. = standard error of the difference between means. * = Indicates significant differences between treatments (P ≤0.05). Meanings with different literals between rows indicate different significant according to Duncan

Table 2: Chemical composition of cassava (*Manihot esculenta*) flour under different levels of organic fertilization based on filter cake **of sugarcane in gleysol soil**

Parameter (%)	Organic fertilization (kg plant^{-1}) 0.0	0.5	1.0	1.5	S.E.M.	Sig.
Crudeprotein	2.3 b	2.1 b	1.8 b	3.4 a	0.3	*
Neutral detergentfiber	12.8 a	15.5 a	18.4 a	17.0 a	1.6	n.s.
Organic material	90.6 a	91.1 a	91.1 a	91.1 a	0.6	n.s.
Ashes	3.4 a	3.5 a	3.3 a	3.4 a	0.1	n.s.

S.E.M. = standard error of the difference between means. * = Indicates significant differences between treatments (P ≤0.05). n.s. = there are no significant differences between treatments (P> 0.05). Means with different letters between rows indicate different significant according to Duncan

The increase in cassava tuber yield due to the application of organic manure has been reported by several authors who indicated that organic fertilizers are a source of rapidly available nutrients, when applied in the growing area; as it improves the quality and soil structure, which is reflected in the growth time of plants (Buitrago, 2001; Valdivié *et al*., 2008). However, the production volumes observed in the study were lower than those reported in San Antonio Palmitos, Colombia, in cultivars under different irrigation intensities, where the dry matter varied between 7.62 and 10.37 t ha^{-1} (Félix *et al*., 2014). The production volume of the present study was in the range of dry matter production reported by another study, with yields of 2.19 t ha^{-1} and 13.39 t ha^{-1} of dry matter (Fuenmayor *et al*., 2012). The yield of the tuber processed into cassava flour obtained in this work fluctuated between 1.34 and 4.11 t ha^{-1}, which gave estimated conversion value of 4.75 tonnes of fresh tuber per 1 ton of cassava flour. Our data was higher than those reported from Colombia; where a conversion value of 2.92 was obtained, with a fresh tuber crop of 10-12 t ha^{-1} and a harvest time of 12 months (CIAT-UNIVALLE-DRI, 1992). Our values were also higher than those obtained in Colombia, under temperate conditions; where a conversion value of 2.6 has been reported for their crop at 9 months post establishment (Buitrago and Lucket, 1998). In both cases, the difference in the conversion values can be attributed to the time of harvest of the crops; since it is known that shorter the harvest time, the lower the amount of dry matter found in the tubers. Hence, more tubers will be needed to achieve the yield of one ton of flour.

The chemical composition showed that the crude protein content of cassava flour in this study was higher than those reported in Venezuela (Benítez *et al*., 2008) and with fluctuating values of 2.64-2.67% in Colombia (Gil and Buitrago, 2002). The higher protein range reported in this work was probably due to a lower cut age and total tubercle utilization (peel and pulp) compared to other studies where 12-month cutting age was used and the processing of the cassava flour involved removal of the husk in which a higher protein concentration is found. The neutral detergent fiber content was 14.43-21.02%, which was well below those reported for processed cassava flour in Venezuela (Parra *et al*., 2002). These differences may be due to the age of harvest of plant. The values of organic matter found in cassava flour for this work ranged between 90.16 – 90.74%, which was higher than the values reported for Venezuela (with an average value of 73.68%); mainly due to the presence of fodder with high moisture content (Parra *et al*., 2002). The ash content was 3.76-3.86%, this value is higher than those reported in Colombia with processed cassava flour, estimated between 3.32 and 3.39% (Gil and Buitrago, 2002), and even lower than those reported In Venezuela with an average of 2.58% (Benítez *et al*., 2008). These differences can also be attributed to the time of harvest and the processing applied in the production of cassava flour.

Conclusion

The application of organic fertilization improved the yield of tuber and cassava flour. The chemical composition of cassava tuber flour did not vary with the application of different filter cake levels as organic fertilizer, with the exception of the crude protein content that increased with high levels of organic fertilization (1.5 kg plant^{-1}).

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