Economic and Yield Benefits of Chicken Manure and Synthetic Fertilizers

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The Toralapa Research Station rises 11250 feet above sea level in central Bolivia. It is home to a germplasm bank of over 800 potato varieties (*Andigena* sub-species) indigenous to Bolivia. Potatoes are the staple crop in the Bolivian highlands. Research at Toralapa is therefore an important investment in the future of potato production and food security for Bolivians (Figure 1).

Figure 1.Germplasm bank at Toralapa Research Station. Over 800 varieties of indigenous Bolivian potatoes are grown at this site.

Over the past few years, the research station and NGO, PROINPA (National Program for Investigation of Andean Products), agreed to establish potato research plots using the Nutrient Management Decision Support System (NuMaSS) software. NuMaSS was developed by the Soil Management Collaborative Research Support Program (SM CRSP) and is a tool that diagnoses soil nutrient constraints and selects the appropriate remedial practices, based on agronomic, economic and environmental criteria, for location-specific conditions. The purpose of the NuMaSS research at this station was to compare current nutrient applications (urea, diammonium phosphate (DAP) and chicken manure) and yields under the traditional management with that recommended and achieved by NuMaSS, which is based on local soil and crop data.

Due to the geography and politics of Bolivia, synthetic fertilizers are not readily available and the prices are some of the highest in the world. Therefore, animal manure, particularly chicken manure, is a very common nutrient applied to the potato crop in the three-year potato-wheat-faba bean (*Vicia faba*) rotation (Figures 2 and 3). Thorough research was conducted with NuMaSS on the optimum yields and fertilizer application rates on this rotation at the Toralapa Station. The optimum potato yield (*Andigena* sub-species variety *Waych'a*) in the first year was 14.06 t/ha with 120 kg nitrogen (N) or 7 t/ha chicken manure (equivalent to 160 kg N) and 86 kg/ha broadcast P. In the third year, a yield of 24.15 t/ha was achieved with 80 kg N or 3.5 t/ha chicken manure and 86 kg/ha of residual P broadcast to the initial potato crop. There was no yield response to N by wheat planted in the second year due to a severe frost during the grain filling stage. When only P was applied, and no fertilizer N or chicken manure, the potato yield was 5.65 t/ha.

Figure 2. Chicken litter, 'gallinaza', before it is applied to a potato field in the Bolivian Highlands.

Figure 3. Bolivian highland farmer planting potato crop in furrows with chicken litter.

Because the economic benefits of these nutrient management treatments were of interest to farmers and researchers working with this rotation, an economic analysis was conducted to determine the net returns when using chicken litter versus synthetic fertilizers versus only DAP (Tables 1, 2 and 3) on the three-year rotation of potato-wheat-beans. Fertilizer costs were based on the current prices of chicken litter, P in DAP and N in urea. Profits were based on the average yields and the cost and amount of fertilizers applied. The current market prices of \$0.21/kg P_2O_5 and \$0.21/kg N were used. The market price of the three crops was \$0.38/kg for potato, \$0.15/kg for wheat, and \$0.16/kg for beans.

Potato yields were the same under both N treatments and were greater than yields obtained with only DAP. Wheat and fresh bean yields were larger using chicken manure and DAP versus urea and DAP or just DAP (Tables 1 and 2), though fertilizer use was also higher under the manure treatment, requiring more money to be spent on fertilizers (\$235). The fertilizer costs under the urea treatment were approximately \$118 and under the DAP only treatment were \$93. Over the three-year rotation, net profits to the farmer, above fertilizer and transport costs, were approximately \$5,339 using readily available manure and synthetic fertilizer P, approximately \$5,366 using synthetic N and P, and approximately \$2,478 using only DAP. Therefore, the substantially greater net profit to the farmer comes when using an N source, either chicken manure or synthetic fertilizer. The amount of N supplied in the manure was 160 kg/ha, while the urea supplied 120 kg N/ha.

A difference does exist between the profits, favoring the synthetic treatment, though it is important to remember that the yields and prices of fertilizer will vary each year. Also, it is more realistic to use the manure treatment, as it is much more readily available throughout the Highlands.

In the second year of the study with potato, 3.5 and 7.5 t/ha of chicken manure (equivalent to 80 and 160 kg N/ha, respectively) were compared along with the synthetic N treatment. The experiments showed that the reduced application of chicken manure produced similar yields to that obtain with 7 t/ha. Applying half the rate of chicken manure would reduce the N fertilizer cost and result in a net profit exceeding that of the synthetic N fertilizer treatment in Table 2. Additional investigations of chicken manure rates in relation to synthetic fertilizer rates would be needed to determine a more realistic net profit for the farmers.

The economic savings reported above could allow farmers to collect soil samples from their land and use accurate field data in their land management decisions each year. On average, a soil sample analysis costs \$22 in Bolivia. All three of the treatments in this study produce a net profit in excess of the soil sample costs. Fertilization based on frequent soil test analysis avoids excessive fertilizer applications and ensures that future nutrient problems will be identified and corrected before they limit crop yields.

Temperature and rainfall data for the Highlands are presented in Figure 4.

Table 1. Net return on three-year potato-wheat-bean rotation in Bolivian Highlands when using chicken manure and diammonium phosphate (DAP) fertilizer. All crops were planted in November. Costs of fertilizers and yield profits are based on current market prices.

Crop	November	February	April	Total profit over 3-yr rotation
Potato (14.06 t/ha)[1]	planting	$4,846	-	
Wheat (2302 kg/ha)[2]	planting	-	$368	
Bean (2246 kg/ha)[3]	planting	$359		
Fertilizer transport	$75	-	-	
Chicken manure (7t)	$142	-	-	
P (86 kg/ha)	$18	-	-	
Totals	**-$235**	**$5,205**	**$368**	**$5,339**

[1]Potato harvest occurs during the first year of the three-year rotation.
[2]Wheat harvest occurs during the second year of the three-year rotation.
[3]Bean harvest occurs during the third year of the three-year rotation.

Table 2. Net return on three-year potato-wheat-bean rotation in Bolivian Highlands when using urea fertilizer. All crops were planted in November. Costs of fertilizers and yield profits are based on current market prices.

Crop	November	February	April	Total profit over 3-year rotation
Potato (14.06 t/ha)[1]	planting	$4,846	-	
Wheat (1799 kg/ha)[2]	planting	-	$293	
Beans (2156 kg/ha)[3]	planting	$345	-	
Fertilizer transport	$75	-	-	
N (120 kg/ha)	$25	-	-	
P (86 kg/ha)	$18	-	-	
	-$118	**$5,191**	**$293**	**$5,366**

[1]Potato harvest occurs during the first year of the three-year rotation.
[2]Wheat harvest occurs during the second year of the three-year rotation.
[3]Bean harvest occurs during the third year of the three-year rotation.

Table 3. Net return on three-year potato-wheat-bean rotation in Bolivian Highlands without the use of N fertilizer. All crops were planted in November. Yield profits are based on current market prices.

Crop	November	February	April	Total profit over 3-year rotation
Potato (5.65 t/ha)[1]	planting	$1,947	-	
Wheat (1743 kg/ha)[2]	planting	-	$279	
Beans (2156 kg/ha)[3]	planting	$345	-	
Fertilizer transport	$75	-	-	
P (86 kg ha^{-1})	$18			
	-$93	**$2,292**	**$279**	**$2,478**

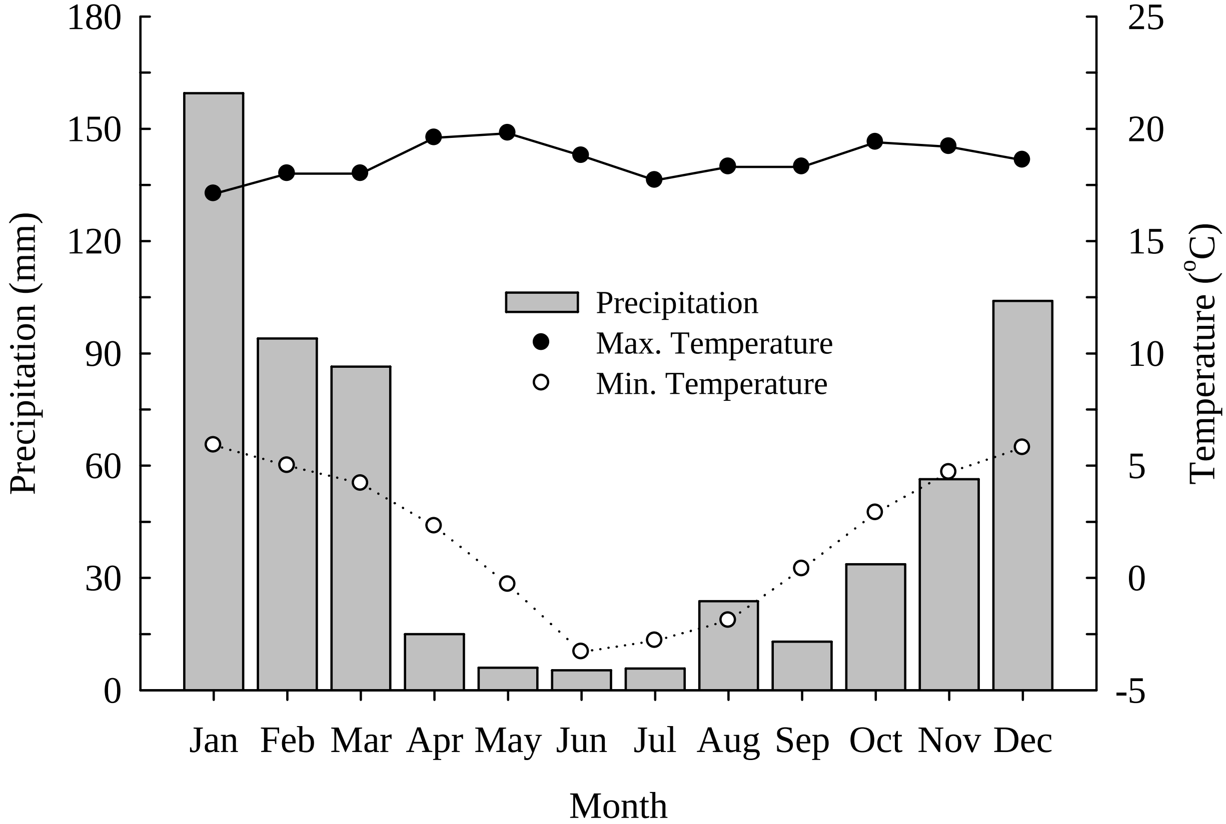

Figure 4. Mean monthly rainfall, and maximum/minimum air temperatures at Toralapa, Bolivia for the period from 1991 to 1997. *Source: PROPINA.*