Tankage: A locally produced nitrogen input for sustainable agriculture in Hawai'i

Ted Radovich, Amjad Ahmad, Alton Arakaki, Jari Sugano, Jensen Uyeda, and Nguyen Hue

Tankage is the solid byproduct of animal waste rendering (Fig. 1). The nutrient content of tankage will vary with feedstock and storage time, but the product in Hawai'i has been fairly consistently analyzed at 9.5, 2.5, 0.75, and 5.0% N, P, K, and calcium (Ca), respectively with a C:N of 5:1 (Arakaki, 2008; Garcia and Rosentrater, 2008). The Hawai'i material is derived from fish scraps (~48%), waste meat, carcasses and other mixed materials (~46%) and offal (~6%) (Baker Commodities, personal communication). Currently there is a single plant in the State producing tankage at an approximate rate of 25 tons/month. Often called meat and bone meal, tankage is a valuable agricultural input (Blatt, 1991; Mondini et al., 2008) used as fertilizer in Hawai'i for at least 20 years (Valenzuela et al., 2001). The material is National Organic Program (NOP) compliant and listed as an approved generic material by OMRI.

Fig. 1: *Meat and bone meal byproducts (Tankage).*

The primary agricultural use of tankage is as a supplemental N source (Jeng et al., 2006), especially for, but not limited to, certified organic growers. Demand for tankage continues to grow proportionally to the rising cost of synthetic fertilizer and the expansion of certified organic and other forms of sustainable agriculture. In seedling media recommendations are 0.75-1.0 pounds of tankage per cubic foot of media (Gurr, 2011). Research on Molokai has identified application rates of 1-2 tons/acre as adequate for annual vegetable growth, with rates of 4 tons/acre suppressing yields (Arakaki, 2008). Preliminary recommendations for most short-cycle vegetable crops are 1500-3850 lbs/acre per crop cycle (Radovich, 2012). Nitrogen mineralization rates for tankage have always been assumed to be high given its low C:N and high nitrogen content, but actual mineralization rates in Hawaii soils have not been readily available. Other gaps in our knowledge of this material include batch-to-batch variability in the material and nitrogen loss during storage.

Nutrient content variability among tankage batches:

Periodic collection approximately every 3 months of tankage (meat and bone meal byproducts) samples from Island Commodities Co., in Kapolei, Oahu, Hawaii was conducted over two years. The initial samples were submitted to the University of Hawaii's ADSC (Agricultural Diagnostic

Services Center) for total nutrient content analysis (Table 1). After the initial analysis, the tankage samples were stored at room temperature in plastic storage containers. Three sub-samples were taken every 3 months for nitrogen analysis to measure the decline/changes in N content over time (Fig 2). The results showed that tankage can provide a fairly good amount of macro- and micro-nutrients, except potassium (K) which is fairly low. Nitrogen (N) content in tankage initial samples varied between 8.7-12.1% with an average of 9.8%, and C:N varied between 3.5-5.3% with an average of 4.7% (Table 1). The periodic analysis of N content in the stored tankage samples under lab conditions showed a significant continuous decline in N content (10-30%) of the initial N (Fig. 2). Under field/farm conditions, the decline would be higher and faster, since weather conditions (heat, humidity, rain, etc) are the main factors leading to increased N loss. It is recommended that tankage be used relatively fresh and not stored over long periods of time.

Table 1: Mean of each collection, Overall mean, Standard Deviation, and CV for Macro-nutrient, C/N ratio (%) and Micro-nutrient (µg/g) content in tankage samples collected over two years.

Collection date	%								µg/g				
	N	C	C/N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B
May 2012	10.6	45.57	4.3	3.21	0.92	6.06	0.18	0.78	1069	12	97	4	5
Aug 2012	10.3	45.50	4.4	3.54	0.83	6.22	0.17	0.77	788	9	96	4	2
Nov 2012	12.1	42.26	3.5	3.22	1.07	5.81	0.19	0.92	662	12	106	4	4
Feb 2013	9.8	47.10	4.7	3.50	0.73	6.18	0.17	0.72	730	8	91	5	3
May 2013	8.7	45.93	5.1	3.16	0.74	5.70	0.17	0.65	745	10	85	1	3
Aug 2013	8.9	46.81	5.3	3.23	0.83	5.88	0.18	0.83	728	8	91	3	4
Nov 2013	8.8	46.13	5.3	3.07	0.81	5.55	0.17	0.72	738	10	85	1	3
Feb 2014	9.3	45.81	4.9	3.09	0.81	5.43	0.17	0.69	667	9	75	2	3
May 2014	9.4	45.93	4.9	3.48	0.85	6.05	0.17	0.72	725	9	88	4	3
Mean	**9.8**	**45.6**	**4.7**	**3.27**	**0.84**	**5.87**	**0.17**	**0.75**	**761**	**9.7**	**90**	**3.1**	**3.3**
Stdev	**1.09**	**1.38**	**0.58**	**0.18**	**0.10**	**0.28**	**0.01**	**0.08**	**121**	**1.5**	**8.8**	**1.5**	**0.8**
CV	**0.11**	**0.03**	**0.12**	**0.06**	**0.12**	**0.05**	**0.04**	**0.11**	**0.16**	**0.16**	**0.1**	**0.5**	**0.2**

*Each value is a mean of three replicates.

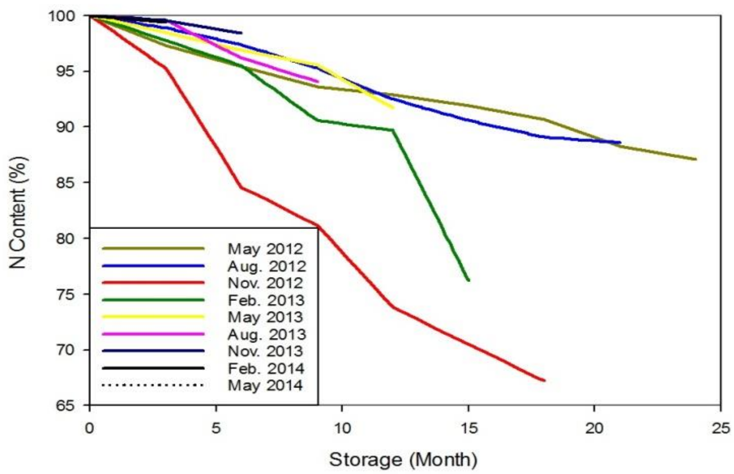

Fig. 2: *Nitrogen loss (%) over time from tankage samples stored at lab temperature (75°F) over two years period.*

Nitrogen mineralization pattern:

To determine the nitrogen release pattern from tankage, a leachate column incubation experiment was conducted at the University of Hawaii-Manoa using tankage applied at 4 application rates (0, 100, 200, and 400 lbs N/acre) under two soils (Wahiawa and Waialua series) with 3 replicates for each application rate. A total of 24 PVC leachate columns were used. Each column measured 1 ft long with a 3 inch inner diameter. The columns were set up from top to bottom with a 2-inch soil and tankage mixed layer, a 5-inch soil layer, a 1-inch gravel layer, and plastic fine mesh to prevent soil passing through. Incubation started with adding half pore volume of deionized water for each column. Subsamples were taken periodically up to 3 months. At each collection time, half pore volume of deionized water was added and leachates were collected with glass beakers. Leachate subsamples were analyzed for pH, electrical conductivity (EC), Nitrate (NO_3-N), and Ammonium (NH_4-N) using Vernier meter and electrodes. Results showed mineralization rates in a 3 month period to be 50-70%. Under field conditions actual mineralization is expected to be at or above the higher end of this range (Fig. 3).

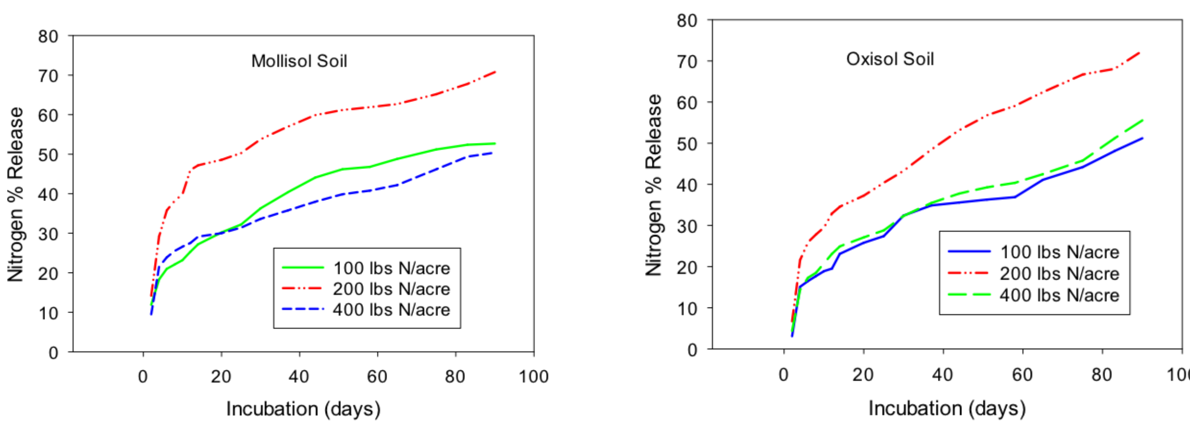

Fig. 3: *NO_3-N (%) released from tankage applied at 0, 100, 200, and 400 lbs N/acre over 90 days leachate column study under Mollisol and Oxisol soils.*

Table (2): Tankage application table. Showing how much N, P, and K was applied (lbs/acre) at each application rate.

Tankage (lbs)/acre	N applied* (lbs/acre)	P applied** (lbs/acre)	K applied*** (lbs/acre)
50	3.75	1.50	0.42
75	5.63	2.25	0.63
100	7.50	3.00	0.84
125	9.38	3.75	1.05
150	11.25	4.50	1.26
175	13.13	5.25	1.47
200	15.00	6.00	1.68
225	16.87	6.75	1.89
250	18.75	7.50	2.10
275	20.63	8.25	2.31
300	22.50	9.00	2.52

* N content is calculated based on average of 10% N and 75% N mineralization rate.
** P content is calculated based on average of 3.0% and 100% mineralization rate.
*** K content is calculated based on average of 0.84% and 100% mineralization rate.

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