MEAT AND BONE MEAL: FERTILIZING VALUE AND RATES OF NITROGEN MINERALIZATION

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ABSTRACT

After the BSE scandal, meat and bone meals were banned from animal feeding and started being incinerated or landfilled, despite their high nutritional contents. In fact, risk-free certified products could be used in agriculture as sources of organic matter, aminoacids and nutrients such as nitrogen and phosphorus. To advance the current knowledge on the agricultural use of meat and bone meals as fertilizers, several experiments have been carried out. Firstly, promising results were obtained in two greenhouse trials, but it was also evidenced that the original residues the meals were made of strongly influenced their value as fertilizers. On another hand, the dynamics of N-mineralization of five meat and bone meals were evaluated in three differently-textured soils during a 20-week aerobic incubation. The amounts of mineralized N ranged from 253 to 338 mg Nkg^{-1}soil (or from 42.6 to 63.9% of the organic N applied). Values of potentially-mineralizable N (N_0) varied from 232 to 302 mg N kg^{-1} soil and mineralization rate constants (k) ranged from 0.179 to 0.796 week^{-1}.

Keywords: *meat and bone meal, nitrogen, mineralization rate.*

INTRODUCTION

As a result from the Bovine Spongiform Encephalopathy (BSE, also known as mad cow disease) food crisis, meat and bone meals were banned from animal feeding and destined to incineration or landfilling. These products have also been used as organic fertilizers, given their high contents of organic matter, aminoacids and nutrients such as nitrogen and phosphorus. Provided that they come from residues certified as BSE risk-free, agricultural use seems to be a more reasonable and environment-friendly alternative than disposal or destruction. More data are needed, nonetheless, to determine their typical characteristics and the best application conditions, particularly nutrient contents and their mineralization rates.

Greenhouse experiments are useful for a quick assessment of the effects of the application of any organic product and the determination of its efficiency relative to that of mineral fertilizer. The study of mineralization dynamics may be nonetheless much more informative on the amounts of nutrients released from the organic product and help to determine the optimal application rates. The literature suggests that N mineralization in amended soils follows approximate first-order kinetics (Van Veel & Paul, 1981 and Sinha et al, 1977), and thus the most interesting parameters (N_0: potentially-mineralizable N and k, mineralization rate) can be calculated by means of a non-linear regression analysis approach (Smith et al., 1980).

The objectives of this study were two: to carry out a preliminary evaluation of two meat and bone meals as fertilizers by means of greenhouse experiments, and to determine the rates of nitrogen mineralization of five different products in three soils of different texture.

MATERIALS AND METHODS

Greenhouse agronomic evaluation

Two meat and bone meals (P2 and P3) were tested in two experiments at the rates of 50, 100, 150 and 200 kg N/ha, and compared with similar rates of mineral fertilizer and a non-fertilized control. In a first experiment lettuce (*Lactuca sativa*) was grown, and the effects on yield and nutrient contents were determined. In a second, two successive crops of corn (*Zea mays*) were cultivated to evaluate direct and residual fertilizing value of the two meals. In all cases four replicates of all treatments were made in 8-kg pots, and phosphorus and potassium fertilizers were applied at the usual rates in all the pots.

Determination of nitrogen mineralization rates

Five meat and bone meals (from P1 to P5) were obtained from several plants at Valencia (Spain). Their analytical properties were very similar, organic N ranging from 8.03 to 11.7%. Three soils were used: S1 (sandy, organic matter: 1.49%, organic N: 0.082%), S2 (sandy-loam, OM: 1.65%, ON: 0.092%) and S3 (loam, OM: 0.38%, ON: 0.020%). The meals were mixed with the soils at a rate of 10 t ha^{-1} (5.6 g Kg^{-1}) in 125-ml plastic pots, and incubated aerobically during 20 weeks at 25º C, keeping the soil moisture at about 2/3 of field capacity. At 2, 4, 8, 12, 16 and 20 weeks of incubation, four pots of every mixture were taken and mineral N ($NH_4^+ + NO_3^- + NO_2^-$) was analyzed by Rhine et al (1998) and Sempere et al (1993) methods. N_0 and k were obtained by means of a non-linear regression analysis.

RESULTS AND DISCUSSION

Greenhouse agronomic evaluation

The main results from the greenhouse experiments are displayed in Table 1. In the first experiment, poor and highly variable yields of lettuce were obtained with the P3 meal, although the

***Table 1**. Selected results of the greenhouse experiments.*

		EXPERIMENT 1(lettuce)				EXPERIMENT 2 (corn stem)							
						1^{er} crop				2º crop			
Fert	Rate	*Yield (g)*	*N (%)*	*K_2O (%)*	*P_2O_5 (%)*	Yield (g)	N (%)	K_2O (%)	P_2O_5 (%)	Yield (g)	N (%)	K_2O (%)	P_2O_5 (%)
C	0	*8.57*	*2.03*	*1.25*	*0.31*	19.2	0.41	1.49	0.19	25.2	0.34	1.43	0.20
M	50	*13.7*	*2.49*	*1.44*	*0.34*	27.4	0.49	1.08	0.27	42.7	0.46	1.26	0.25
	100	*14.0*	*2.66*	*1.39*	*0.42*	35.4	0.42	1.46	0.24	52.3	0.53	1.30	0.27
	150	*16.6*	*2.87*	*1.41*	*0.46*	39.9	0.46	1.08	0.27	60.7	0.81	1.36	0.31
	200	*18.2*	*3.43*	*1.39*	*0.52*	48.4	0.87	0.77	0.39	66.6	0.95	1.41	0.31
P2	50	*14.4*	*2.52*	*1.32*	*0.36*	22.7	0.35	1.44	0.22	29.5	0.37	1.44	0.24
	100	*14.8*	*2.07*	*1.49*	*0.40*	32.1	0.61	1.07	0.32	37.3	0.34	1.20	0.22
	150	*17.7*	*3.27*	*1.46*	*0.40*	40.9	0.67	1.52	0.19	36.1	0.37	1.07	0.31
	200	*16.3*	*3.77*	*1.28*	*0.50*	49.1	0.72	0.84	0.29	40.6	0.37	1.00	0.28
P3	50	*6.14*	*3.34*	*0.89*	*0.46*	22.9	0.39	1.23	0.24	30.1	0.36	1.41	0.23
	100	*12.7*	*3.62*	*0.94*	*0.48*	26.0	0.41	1.56	0.21	29.6	0.39	1.23	0.23
	150	*8.27*	*3.86*	*1.09*	*0.54*	21.4	0.67	1.16	0.28	39.3	0.46	1.34	0.20
	200	*6.57*	*4.23*	*1.30*	*0.44*	30.5	0.74	0.82	0.34	46.3	0.51	1.14	0.23
LDS 5%		*3.75*	*0.30*	*0.09*	*0.04*	6.78	0.09	0.26	0.03	4.99	0.06	0.16	0.06

All data expressed in dry matter basis. Fert: fertilizer; C: non-fertilized control; M: mineral fertilizer plant contents of N were clearly increased. On the contrary, similar results to these from mineral fertilization were obtained with the P2 product. In the second experiment, corn yields were acceptable, but comparatively lower than those from mineral fertilization, P3 being again the worst product in the first crop. Nevertheless, the high residual fertilizing value of both meals was evidenced by the good yields of corn obtained as second crop.

Determination of nitrogen mineralization rates

Figure 1 shows how inorganic N was released during the incubation of the soil/meal mixtures. In all cases there was a very good adjustment of the data obtained to the theoretical relationship between N mineralized and time indicated by first-order reaction kinetics. There were small differences among the assayed soils and meat and bone meals, although soil texture seemed to influence the initial fast release of N. All mixtures exhibited a rapid, initial release of inorganic N, followed by a relatively constant rate of mineralization after 3-6 weeks of incubation.

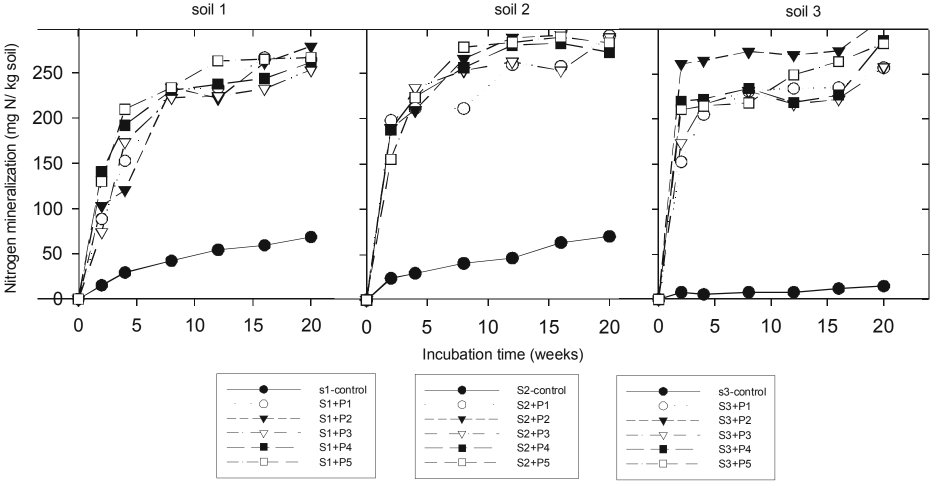

***Figure 1**. Cumulative amounts of N mineralized in the three soils used during aerobic incubation.*

***Table 2**. N mineralization in meat and bone meal by incubation procedure.*

Fertilizer	Soil	N mineralized[a]		Organic N[b]	N_o[c]	k[d]	N_ok[e]	r
		2 weeks	20 weeks	mineralized				
P1	S1	88.3	264	51.1	269	0.211	56.8	0.996
	S2	198	292	56.4	253	0.636	161	0.964
	S3	152	257	49.7	241	0.488	118	0.996
P2	S1	103	279	42.6	277	0.179	49.6	0.984
	S2	189	338	51.7	302	0.369	111	0.977
	S3	261	312	47.6	280	1.28	358	0.990
P3	S1	74.0	253	50.1	246	0.251	61.7	0.989
	S2	190	290	57.5	265	0.597	158	0.992
	S3	174	258	51.1	232	0.686	159	0.989
P4	S1	141	261	58.1	247	0.394	97.3	0.996
	S2	190	273	60.7	274	0.512	140	0.994
	S3	220	287	63.9	239	1.20	287	0.968
P5	S1	130	267	53.5	264	0.352	92.9	0.997
	S2	155	284	57.0	288	0.384	111	1.00
	S3	210	283	56.9	250	0.796	199	0.971

[a] Mineralized N - Control Mineralized N, in mg N kg^{-1} soil. [b] (N mineralized / organic N added) x 100. [c] Potentially mineralizable N obtained from nonlinear least squares regression (mg N kg^{-1} soil). [d] First-order rate constant obtained from nonlinear least squares regression (week^{-1}). e(mg N kg^{-1} soil week^{-1})

Potentially-mineralizable (N_o) values ranged from 232 to 302 mg N kg^{-1} soil, with a mean value of 262 ± 20 ppm (Table 2). Mineralization rates (k) ranged from 0.179 to 1.28 $week^{-1}$ with an average of 0.556 ± 0.329 $week^{-1}$. Soil texture clearly influenced mineralization rates, with averages of 0.277 $week^{-1}$ in the sandy soil, 0.500 $week^{-1}$ in the sandy-loam and 0.890 $week^{-1}$ in the loam. The product of N_o and k is the amount of N potentially mineralizable in 1 week under optimum soil temperature and moisture conditions (Mary et al, 1979; Stark et al, 1980).

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REFERENCES

Mary, B., Rémy, J.C. 1979. Essai d`appréciation de la capacité de minéralisation de l`azote de grande culture. I. Signification des cinétiques de minéralisation de la matière organique humifiée. Ann. Agron., 30: 513-527.

Rhine, E.D., Sims, G.K., Mulvaney, R.L., Pratt, E.J. 1998. Improving the Berthelot Reaction for Determining Ammonium in soil extracts and water. Soil Sci. Am. J., 62: 473-480.

Sempere, A., Oliver, J., Ramos, C. 1993. Simple determination of nitrate in soils by second-derivative spectroscopy. J. Soil Sci., 44: 633-639.

Sinha, M.K., Sinha, D.P., Sinha, H. 1977. Organic matter transformations in soils (V): kinetics of carbon and nitrogen mineralization in soils amended with different organic materials. Plant Soil, 46: 579-590.

Smith, J.L., Schnabel, R.B., McNeal, B.L., Campbell, G.S. 1980. Potentials error in the first-order model for estimating soil nitrogen mineralization potentials. Soil Sci. Soc. Am. J., 44: 996-1000.

Stark, S.A., Clapp, C.E. 1980. Residual nitrogen availability from soils treated with sewage sludges in a field experiment. J. Environ. Qual., 9: 505-512.

Van Veen, J.A., Paul, E.A. 1981. Organic carbon dynamics in grassland soils (I): Background information and computer simulation. Can. J. Soil Sci., 61: 185-201.