Rate of Humification of Manures.

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It has been recognized for a long time that organic matter is an important constituent of the soil, but as to just what way it aids in crop production, there seems to be considerable difference of opinion. Some maintain that it is valuable only for the plant food it carries, while others value it more especially for the plant food in the soil which may be made available by its decomposition. The following paragraph from the Iowa Station, found in the September, 1915, Journal of the American Chemical Society expresses the sentiment of many soil investigators as to the value of humus, and the rate of humification. "The organic matter extracted by alkali is of no very different character than the organic matter of the soils as a whole. This together with the fact proved by Fraps and Hammer, Texas Bul. 129, that upon adding organic matter to soil, at the end of a years time there is no more material extracted with diluted ammonia than at the beginning of the period, proves quite conclusively that the determination of the amount of humus as found by the various methods is of no particular value in the study of a soil." This statement seems rather unreasonable to the author of this article, since the elements that are of value as fertilizers are locked up in most farm manures, green manures, cotton seed meal, etc., as complex compounds and hence are unavailable to the growing plant which must have its food supplied in a very simple form. In well rotted manures these complex molecules are largely broken down to simpler substances containing the same elements, but with a different arrangement in the molecule. They are quite soluble in water and if not leached by rains are very effective as a fertilizer compared with fresh manure.

Therefore, since fertility is so closely related to the unlocking of these complex plant molecules in the manures, an effort was made to measure the rate of humification of the more common ones.

Plan of Procedure.

A clay soil was chosen that was very deficient in organic matter and was, therefore, humus-hungry. With this soil were mixed different manures so

that each double box, holding about 1 cubic foot, contained the same amount of organic matter. The contents of the boxes were as follows:

TABLE I.

Box 1 contained 2 lbs. hen manure + 50 gr. $CaCO_3$.
Box 2 contained 3.2 lbs. sheep manure.
Box 3 contained 2.4 lbs. hog manure.
Box 4 contained 3.0 lbs. horse manure.
Box 5 contained 6.6 lbs. steer manure + 50 gr. $CaCO_3$.
Box 6 contained 6.0 lbs. cow manure + 50 gr. $CaCO_3$.
Box 7 contained 4.0 lbs. horse manure + 101 gr. CaO, MgO.
Box 8 contained 4.0 lbs. horse manure + 171 gr. CaO.
Box 9 contained 4.0 lbs. horse manure + 179 $CaCO_3$, $MgCO_3$.
Box 10 contained 4.0 lbs. horse manure + 175 gr. $CaCO_3$.
Box 11 contained no treatment.

On May 30, 1914, the manure, limestone and soil were well mixed and the boxes were placed in the ground out of doors in order to approximate field conditions. At the same time samples of the mixed soil were taken for humus determinations. Other samples were taken on the following dates: November 25, 1914; February 16, 1915, after winter freeze; April 13, 1915, after a period of quite warm weather; June 1, 1915, October 15 and November 22, 1915.

Humus Determination.

Effort was made to follow the course of changes brought about by bacteria and the weathering agencies, etc., by determining the amount of humus present at the various periods. The term *humus*, as used by American soil investigators, does not refer to the total organic matter present in a soil, but only to that which is soluble in 4 per cent NH_4OH, the calcium and magnesium having been removed. The Official Method as modified by Smith was used in all the determinations. The following tables give averages for the different periods:

TABLE II.

GRAMS OF HUMUS AND ASH IN 1 GRAM SOIL.

	Hen + 50 $CaCO_3$ 1		Sheep + 50 $CaCO_3$ 2		Pig + 50 $CaCO_3$ 3		Horse + 50 $CaCO_3$ 4		Steer + 50 $CaCO_3$ 5		Cow + 50 $CaCO_3$ 6	
	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.
Soils, manures unexposed.	.0057	.0083	.0068	.0080	.0051	.0088	.0058	.0087	.0092	.0076	.0079	.0087
May 30-Feb. 16.....	.0069	.0080	.0078	.0065	.0081	.0060	.0061	.0065	.0093	.0076	.0092	.0074
Feb. 16-April 13.....	.0073	.0112	.0072	0.100	.0083	.0107	.0063	.0101	.0094	.0100	0096	.0115
April 13-June 1.....	.0078	.0096	.0066	.0096	.0073	.0096	.0068	.0088	.0097	.0098	.0097	.0102
June 1-Oct. 15.....	.0071	.0073	.0075	.0087	.0064	.0083	.0089	.0080	.0092	.0094	.0091	.0086
Oct. 15-Nov. 22.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Check.....	.0049	.0097					No treatment.					

TABLE 3.

	Horse + 101 CaO, MgO 7		Horse + 171 CaO 8		Horse + 179 $CaCO_3$, $MgCO_3$ 9		Horse + 175 $CaCO_3$ 10	
	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.
Soil. manure unexposed.	.0055	.0085	.0048	.0078	.0055	.0075	.0055	.0072
May 30 to Feb. 16.	.0064	.0084	.0051	.0065	.0067	.0087	.0051	.0065
Feb. 16 to April 13.	.0070	.0090	.0061	.0096	.0066	.0099	.0061	.0103
April 13 to June 1.	.0072	.0094	.0058	.0093	.0123	.0062	.0069	.0096
June 1 to Oct. 15.	.0090	.0072	.0081	.0083	.0093	.0087	.0074	.0090
Oct. 15 to Nov. 22.	...	...	...	...	...	...	...	...
Check.	.0049	.0097	No treatment					

TABLE 4.

PERCENT OF INCREASE OR DECREASE IN HUMUS.

Hen. 1	Sheep. 2	Pig. 3	Horse. 4	Steer. 5	Cow. 6	
.08	.20	.02	.09	.43	.30	NH_4OH soluble humus before exposure. Over check.
.12	.09	.30	.03	.01	.13	May 30 to Feb. 16.
.04	—.06	.02	.02	.01	.04	Feb. 16 to April 13.
.05	—.06	—.10	.05	.03	.01	April 13 to June 1.
—.07		.09	.15	—.05	—.06	June 1 to Oct. 15.
...	...			...		Oct. 15 to Nov. 22.
601.9	113	1174	165.9	928	620.9	Grams of corn and stalks produced 1915
456	401	281	222	260	249	produced 1916

TABLE 5.

PERCENT OF INCREASE OR DECREASE IN HUMUS.

Horse 7 CaO, MgO	Horse 8 CaO	Horse 9 $CaCO_3$, $MgCO_3$	Horse 10 $CaCO_3$	
.06	—.01	.06	.06	NH_4OH soluble humus before exposure Over check.
.09	.03	.12	—.04	May 30 to Feb. 16.
.06	.10	—.01	.10	Feb. 16 to April 13.
.02	—.03	.57	.04	April 13 to June 1.
.18	.23	—.30	.05	June 1 to Oct. 15.
.....	.....	.....	.....	Oct. 15 to Nov. 22.
123.1	46.6	637.6	386	Grams of corn and stalks produced 1915
308	392	347	320	produced 1916
Check box 145.4....	.....	.....	.....	Grams of corn and stalks produced 1915
151.....	.....	.....	.....	produced 1916

It will be noticed in Table 4 that fresh steer manure is quite soluble in NH_4OH and the solubility is not increased appreciably on exposure in the soil. The same is true to a large extent of cow manure, but less of pig manure while horse manure is only broken down after about 12 to 18 months' exposure, except in the case of Box 9 which was treated with dolomitic limestone. It will also be noticed in Table 5 that when the acidity was corrected with 171 grams of CaO in Box 8 and 101 grams of CaO, MgO in Box 7, the rate of humification was retarded—the CaO and CaO, MgO both having an antiseptic action when more is added than is needed to correct the soil acidity. Chemically equivalent amounts of Ca and Mg (in neutralizing power) were added to Boxes 7, 9 and 10. It would seem that the growth of corn obtained in Box 9 was due to the early humifying of the manure (June 1). While in Boxes 4, 7 and 8 the humification came too late to benefit this year's crop. The yields in Boxes 3 and 5 were the largest of all but it is probable that the higher nitrogen content was the main cause.

Conclusions.

1. Growth of corn, other factors being constant, seems to be proportional to the rate of humification of manures.

2. The ammonia soluble matter in cow and steer manure is not appreciably increased on 18 months' exposure, but hog, sheep and horse manure humify less rapidly and in the order named.