SUBSTITUTES for Stable Manure

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SUBSTITUTES FOR STABLE MANURE IN COMMERCIAL VEGETABLE FARMING

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Commercial vegetable growing in Connecticut dates from colonial times. In the early days, onions, potatoes and turnips were shipped to New York by boat from shore and river towns. Slowly the industry developed around our growing cities, supplying "green" vegetables for urban tables. The motor truck expanded Connecticut's market into other states and, by 1925, vegetable growing had become one of our five major farm enterprises. The past quarter century has seen further expansion.

But with these gains have come losses, one of which is the disappearance of the manure supply. The early market gardeners kept some livestock. Later they depended on city stables. By 1925 the motor vehicle had practically displaced the horse. This meant that almost complete dependence was placed on fertilizers and winter cover crops. Commercial fertilizers, of course, had long been used to supplement manure.

In 1924 Morgan and his associates began a study of the important soil types of the state. One finding was that our intensively cropped vegetable farms were steadily losing organic matter. This posed a serious practical problem. From 1930 to 1939 a series of field experiments was conducted at Windsor to determine the effect of intensive cropping with and without manure. The results were published in 1940 as Station Bulletin 439, "Soil Management for Intensive Vegetable Production on Sandy Connecticut Valley Land".

These experiments covered several phases of soil management but for our purpose the following quotation from Bulletin 439 will suffice:

> "A combination of moderate manuring and medium rates of complete fertilizer application is most effective in producing high yields of miscellaneous vegetable crops without depletion of the soil.
>
> "A combination of green manuring, winter cover crops and liberal rates of application of well-balanced complete fertilizer is successful in maintaining favorable yields of most vegetable crops. However, the organic content of the soil suffers some depletion under intensive vegetable cropping *unless* manure or other organic soil amendment is applied to the soil at frequent intervals."

The cropping was intensive – two or three crops per year. All plots were sown to winter rye cover crops. Plots receiving no manure but ample commercial fertilizer lost organic matter steadily and deteriorated in physical condition. This was happening on many vegetable farms.

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[1]Soil Scientist. Grateful acknowledgment is made to the late M.F. Morgan who planned this experiment and directed it during the early phases. Dr. Morgan lost his life on the Island of Leyte in the Philippine Islands, January 15, 1945, while on active duty in the Army.

In striking contrast were Morgan and Jacobson's observations on tobacco fields, also cropped continuously. The organic matter of these fields was about at the optimum and not declining. The reasons are obvious:

(a) Tobacco is on the land but two months. A heavy cover crop, usually oats, is on the fields for seven or eight months.

(b) The tobacco stalks are returned to the soil.

(c) From 1500 to 2000 pounds per acre of organic fertilizer is used – cottonseed, soybean or castor bean meals and fish meal – in addition to other fertilizers. (The normal application supplies 200 pounds of nitrogen, 120 pounds of phosphoric acid, and 200 pounds of potash.)

Practice on intensive vegetable and potato farms is quite different. The fields are in row crops six to eight months of the year; winter rye is often sown so late that little growth occurs before winter sets in; and the fertilizers used are chiefly inorganic.

The experiments at Windsor, with other soil studies and observations, suggested three roads to better soil management on such fields:

(1) Manure; or

(2) A rotation system that maintains organic matter; or

(3) "Manure substitutes".

The manure shortage and the decline of soil organic matter seemed so serious – they still are – that in 1938 Morgan and Jacobson began an experiment at Windsor, designed to test the value of several "manure substitutes". The author was responsible for its completion. The following pages describe this experiment and state the results obtained.

THE EXPERIMENT

Materials Used

New England abounds in deposits, usually small, of peat and muck.[1] About 1934 Morgan made a survey of these in Connecticut and found many of the so-called mild type. A few deposits have been exploited commercially following his publication.[2] The primary purpose of this new experiment was to test the practicability of using native peats and mucks in modern farming systems. Other "manure substitutes" suggested themselves and were included as listed below. The questions to which answers were sought were:

1. How would these "substitutes" affect the organic matter content of the soil?

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[1]In the days of cheaper labor, but not of power machinery, many New England farmers used them—usually mixed with manure. Sea weed also was used on farms near the coast.
See: Peat and Its Use, S. W. Johnson. Orange Judd and Co., New York, 1866.
Manure from the Sea, E.H. Jenkins. Conn. Agr. Expt. Sta. Bul. 194. 1917.

[2]Peat and Swamp Muck for Soil Improvement in Connecticut, M.F. Morgan. Conn. Agr. Expt. Sta. Circ. 142. 1940.

2. How would they affect yields?

Five materials were selected:

1. *Native Peat Moss - A;* from a bog on the Henry Trumbull farm in Plainville. It is more humified than No. 2.
2. *Native Peat Moss - B;* from a deposit on the Merritt Chalker farm in Saybrook.
3. *Commercial Dried Sheep Manure.* This is from stock yards and feeding pens. It is carried by most dealers in fertilizers.
4. *Commercial Dried Cow Manure.* Like sheep manure, this is easily available, under several trade names – in this case "Bovung".
5. *Ground Tobacco Stems.* These are the midribs of tobacco used in the manufacture of cigars. They are ground and are on the market as an organic fertilizer.

TABLE 1. ANALYSES OF "SUBSTITUTES"[1]

Material	Per Cent Ash	Per Cent Volatile Matter	Per Cent N	Per Cent P_2O_5	Per Cent K_2O	Approx. Per Cent Water As Received
1. Native peat moss - A	14.26	85.74	0.69	0.12	0.03	60
2. Native peat moss - B	4.11	95.89	0.44	0.096	0.0285	60
3. Commercial dried sheep manure	20.80	79.20	1.90	1.50	2.00	10
4. Commercial dried cow manure	53.40	46.60	2.12	3.17	3.07	10
5. Ground tobacco stems	7.60	92.40	1.80	0.66	5.68	8 to 10

[1]All analyses were on water free basis.

A series of 18 plots, each 20 by 25 feet, was laid out. There were six treatments, the five substitutes and one of fertilizer only. Thus, each treatment was in triplicate.

An amount of each substitute was applied to supply 5,250 pounds of dry matter (water free). It was decided to fertilize each plot at the rate of one ton per acre of a 5-5-10 grade. Actually the rate was 105 lbs. N; 105 lbs. P_2O_5; 210 lbs. K_2O. Based on the analyses of the substitutes, sufficient fertilizer materials were added to each to make all plots equal in plant nutrients supplied. All applications were made annually.

In 1939 all plots received lime sufficient to bring the reaction to 6.5 pH. Each year thereafter dolomitic limestone equivalent to the residual acidity of the fertilizers used was applied. Table 2 gives the details of the plot treatments.

Each fall all plots were seeded to a winter cover crop of rye. This was plowed under the following spring. All materials, including inorganic fertilizers, were broadcast on the surface each spring after plowing and disked in.

TABLE 2. KINDS AND AMOUNTS OF FERTILIZERS AND MANURE SUBSTITUTES APPLIED TO THE PLOTS[1] DURING THE 9-YEAR PERIOD, 1938-1946

Inorganic and Organic Material Used	Fertilizer Only	Native Peat Moss A	Native Peat Moss B	Commercial Dried Sheep Manure	Commercial Dried Cow Manure	Ground Tobacco Stems
Plot numbers	1, 11, 15	4, 9, 16	2, 7, 14	6, 10, 13	3, 8, 18	5, 12, 17
Fertilizer material applied			*Pounds per acre*			
Nitrate of soda (16% N)	130.7	130.7	130.7	130.7	130.7	130.7
Sulfate of ammonia (20% N)	148.1	226.5	148.1	191.6	191.6	174.2
Superphosphate (20% P_2O_5)	522.6	418.1	522.6	272.6	272.6	377.1
Soybean meal (7% N)	87.1	87.1	87.1	87.1	87.1	87.1
Urea (42% N)	87.1	52.3	156.8	34.8	17.4	87.1
Muriate of potash (60% K_2O)	348.5	331.1	348.5	200.3	200.3	0
Dolomitic limestone[2]	304.9	253.1	357.1	209.1	191.6	217.8
Approximate amount of substitute added[3]	0	5,250	5,250	5,250	5,250	5,250
Average amount of fertilizer constituents added by organic material						
N	0	17.5	25[4]	30	37	15.0
P_2O_5	0	22.5	0	50	50	30.0
K_2O	0	10.0	0	87	87	280.0[5]

[1]Average amount of fertilizer constituents available in the combined application of substitutes and fertilizers on a pounds per acre basis: N, 105; P_2O_5, 105; K_2O, 210.

[2]Average amount of dolomitic limestone added equivalent to the residual acidity of the inorganic fertilizers.

[3]Water free basis.

[4]Additional amount added to hasten the decomposition of this peat moss.

[5]On an equivalent 5,250 pounds of organic material, higher amounts of potash were included because of the high potash content of tobacco stems.

The plot layout is shown in Figure 1. The soil of the field used at the Station's Tobacco Laboratory, Windsor, is Merrimac sandy loam,[1] typical of many vegetable farms in Connecticut. Its organic matter content is about 2 per cent. The field is practically level and thus subject to little or no runoff or erosion. Soil samples were taken to a six-inch depth at the beginning and end of the experiment. (See Table 4).

Crops Grown

Sweet corn, cabbage and carrots were the "indicator" crops used. Each plot grew all three crops each year, but they were alternated or rotated as to position. It will be noted that the use of the land was not extremely intensive. That is, but one crop per year was grown. On

[1]Merrimac sandy loam is a member of the Brown Podzolic great soil group. The profile is well drained, strongly acid and has a weak very fine crumb to single grain structure. It is derived from deep stratified medium sand and gravel deposits of granite, gneiss, and schist materials. Topographically, these soils are located on the extensive glaciofluvial terraces of the Connecticut Valley. The surface soil is dark brown sandy loam (10 YR 4/3) (Munsell color notations for moist soil. U.S. Dept. Agri. Handbook No. 18. Soil Survey Manual. 1951.) The subsoil is strong brown (7.5 YR 5/6-5/8) sandy loam, and the parent materials are mainly coarse sand with some fine gravel. The color of the material varies from nearly white quartz grains to yellow colored (10 YR 7/6-8/6) material. The entire profile is rapidly permeable to water.

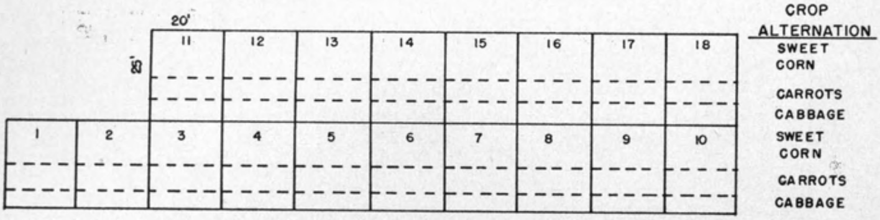

FIGURE 1. PLOT LAYOUT AND SEQUENCE OF THE THREE CROPS GROWN

Plot 20 ft. x 25 ft. = 500 sq. ft.

Each plot:
- 4 rows of sweet corn 30 in. apart - 10 ft.
- 4 rows of cabbage 24 in. apart - 8 ft.
- 6 rows carrots 14 in. apart - 7 ft.

Total plot width 25 ft.

Plots	Treatment[1]
1-11-15	Fertilizer only
4- 9-16	Native peat moss - A + fertilizer
2- 7-14	Native peat moss - B + fertilizer
6-10-13	Commercial dried sheep manure + fertilizer
3- 8-18	Commercial dried cow manure + fertilizer
5-12-17	Ground tobacco stems + fertilizer

some commercial vegetable farms an early crop might be followed by a late one, and late potatoes might be on the land longer each year than in the case of the crops used in the experiments. However, the experimental cropping was continuous with only the winter rye cover crop intervening.

Planting was done between early and mid-May, depending on the season. Harvesting of sweet corn and cabbage varied from late July to late August; of carrots, from early August to mid-September. The entire plots of corn and cabbage were harvested; of carrots, four randomized strips, each four feet long.

THE EFFECT OF THE "SUBSTITUTES" ON YIELDS

Table 3 presents the yield data for the nine years, by weight and by percentage of the "fertilizer only" plots, which were used as the control. With the exception of tobacco stems on carrots, all of the "substitutes" increased yields over fertilizer alone. The percentage increases over "fertilizer alone" are listed for each crop under each substitute treatment. These are the averages of nine years.

THE EFFECT OF THE "SUBSTITUTES" ON ORGANIC MATTER CONTENT OF THE SOIL

Table 4 shows the per cent of organic matter present in the plots at the beginning and end of the experiment. As will be noted, this soil contained about 2 per cent of organic matter before the experiment. This is normal for Merrimac sandy loam which has been reasonably well managed. It will be noted that the "fertilizer only" plots

[1]See Table 1 for details.

Table 3. YIELDS[1] OF SWEET CORN, CARROTS AND CABBAGES GROWN[2] AS TEST CROPS, 1938-1946

Treatment	Fertilizer Only		Native Peat Moss A		Native Peat Moss B		Commercial Dried Sheep Manure		Commercial Dried Cow Manure		Ground Tobacco Stems	
Year	lbs./A	%[3]	lbs./A	%	lbs./A	%	lbs./A	%	lbs./A	%	lbs./A	%
					Sweet Corn (ears only)							
1938	4611	100	6264	135.8	5220	113.2	6264	135.8	5198	112.7	5829	126.4
1939	6438	100	9853	153.0	9048	140.5	10788	167.6	10222	158.8	7960	123.6
1940	6199	100	9135	147.4	8613	138.9	8700	140.3	9483	153.0	8200	132.3
1941	9070	100	11593	127.8	11897	131.2	9940	109.6	12180	172.3	10657	117.5
1942	3850	100	7765	201.7	7439	193.2	6351	165.0	7634	198.3	5524	143.5
1943	6960	100	6090	87.5	6960	100	6742	96.9	7112	102.2	6155	88.4
1944	4850	100	4959	102.2	5394	111.2	5089	104.9	5220	107.6	4502	92.8
1945						no crop harvested[4]						
1946	5438	100	5720	105.2	7547	138.8	7177	132.0	9418	173.2	6025	110.8
Average	5927	100	7672	129.4	7765	131.0	7631	128.7	8308	140.2	6857	115.7
					Carrots (roots and tops)							
1938	6835	100	7923	115.9	8171	119.5	6618	96.8	10657	155.9	7923	115.9
1939	18331	100	16560	90.3	18021	98.3	21407	116.8	15007	81.9	15721	85.8
1940	13515	100	12956	95.9	15131	111.9	14758	109.2	17927	132.6	13111	97.0
1941	16995	100	13453	79.2	19325	113.7	10719	63.1	16467	96.9	9538	56.1
1942	51825	100	63196	121.9	57977	111.9	49028	94.6	57977	111.9	33183	64.0
1943	29206	100	45672	156.4	35730	122.3	38837	133.1	37595	128.7	30759	105.3
1944	12863	100	12304	95.6	10719	83.3	10439	81.2	10253	79.7	9787	76.1
1945	26844	100	27683	103.1	28243	105.2	33089	123.3	29641	110.4	33276	124.0
1946	15659	100	22370	142.9	16343	104.4	18766	119.8	15970	102.0	13484	86.1
Average	21134	100	24680	116.8	23295	110.2	22629	107.1	23499	111.2	18531	87.7

						Cabbage Heads						
1938	30274	100	38706	127.8	35822	118.3	31362	103.6	37454	123.7	35904	118.6
1939	27798	100	26493	95.3	23474	84.4	23365	84.0	24262	87.3	26085	93.8
1940	12050	100	20808	172.7	19638	163.0	21760	180.6	15586	129.3	15776	130.9
1941						no crop harvested[5]						
1942	17952	100	21216	118.2	22304	124.2	20944	116.7	20128	112.1	25296	140.9
1943	15232	100	13981	91.3	17381	114.1	18278	120.0	20971	137.7	17163	112.7
1944	23392	100	28886	123.5	26792	114.5	30464	130.2	30192	129.1	22254	95.1
1945	8105	100	20590	254.0	20481	252.7	17326	213.8	23582	290.9	19774	243.9
1946	8242	100	15830	192.1	13464	163.3	16810	204.0	20427	247.8	18904	229.4
Average	17886	100	23314	130.3	22419	125.3	22539	126.0	24075	134.6	22644	126.6
Total 3 crops	44947	100	55666	123.8	53476	119.0	52799	117.5	55882	124.3	48032	106.9

[1]Green weight basis.
[2]See Table 2, page 6, for details on fertilizers used.
[3]Fertilizer only treatment used as the control.
[4]Crop failure due to damage by crows.
[5]Crop failure due to damage by rabbits.

lost organic matter; all other plots received nine annual applications of dry organic matter at the rate of 5,250 pounds per acre, a total of 47,250 pounds. If, at 2 per cent, a six inch depth of this soil originally contained 40,000 pounds of organic matter per acre, the 47,250 pounds is a substantial addition. The tobacco stems and sheep manure plots showed a measurable loss in organic matter at the end of the experiment; dry cow manure and both native peat mosses showed substantial increases, the two peats being about twice the dried cow manure.

TABLE 4. CHANGES IN ORGANIC MATTER[1] CONTENT OF THE SOIL DUE TO THE SEVERAL TREATMENTS[2]

Year	Fertilizer Only	Native Peat Moss - A	Native Peat Moss - B	Commercial Dried Sheep Manure	Commercial Dried Cow Manure	Ground Tobacco Stems
			Per cent			
1939	1.97	1.92	2.07	2.15	1.83	2.02
1946	1.82	2.59	2.64	1.90	2.13	1.88
Increase + or Decrease −	− 0.15	+ 0.67	+ 0.57	− 0.25	+ 0.30	− 0.14

[1]Schollenberger, C. J. Determination of soil organic matter. Soil Sci. 31:483-486. 1931.
[2]See Table 2 for details on fertilizer materials used.

PRACTICAL CONSIDERATIONS

Morgan and Jacobson's earlier results led them to the conclusion that under the conditions of that experiment, 16 tons per acre of manure, applied annually, maintained the organic content of these soils. Therefore, an amount of each of the manure substitutes was used that would supply the same dry matter as contained in 16 tons of average fresh cow manure.

The commercial dried cow manure used (Bovung in this case) may therefore be considered equivalent in dry matter to 16 tons of fresh cow manure. Referring to Tables 3 and 4, we find that Bovung increased the yields over fertilizer alone and that the soil organic matter content increased.

In Connecticut today some growers are buying surplus fresh manure from nearby dairy farmers. The cost delivered to the vegetable farm is about $12 a cord.[1] Sixteen tons of manure will average to bulk 5 cords. Therefore, the cost would be 60 dollars at the vegetable farm.

The other "substitute" that gave about the same increases in yields and soil organic matter was native peat moss. It was applied at the rate of 27 cubic yards per acre, a rate that furnished the same amount of dry matter as 16 tons of fresh or dry manure.

Native peat moss can be dug and hauled for $1.50 to $2.00 per cubic yard. Twenty-seven cubic yards would cost, at the farm, not more than 54 dollars and from a reasonably dry bog, about 40 dollars.

Since dried cow manure is rather expensive and fresh manure is not always available, it would seem that Connecticut's numerous small bogs are a practical source of organic matter.

[1]New England farmers usually measure manure in cords of 128 cubic feet. The cubic content of a cart — today a truck — is known and a hay scale is often not conveniently located.