COMPARATIVE SOIL TESTS 1951-1961 OF A BIO-DYNAMIC FARM

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Previously, in BIO-DYNAMICS #59 (1), the yields of the N. V. Loverendale were reported. These showed a steady increase over a twenty-five year period of B. D. management. It is of interest to investigate the soil condition which was able to produce these results. It was not possible to make soil analyses every year, but we have received soil samples in 1951 and again in 1961, so that we could compare the conditions at the time when good average yields were the rule with those ten years later, when maximum yields were obtained.

These analyses were carried out at the Biochemical Research Laboratory, Spring Valley, N. Y., which does all the research work for the B.D. Farming and Gardening Association. The methods used for the determination of available nutrients are routine extraction with La Motte universal extracting solution and colorometric determination of nitrate, phosphate and potash. These results are expressed in lbs./acre. The determination of total nitrogen, phosphate and potash was done by the official methods of the AOAC (2). These results are expressed in % of the sample. Phosphate and potash are reported as P_2O_5 and K_2O.

The results are contained in the tables 1 through 4. Of the three farms of Loverendale (designated with the letters PH, TL and TM), three representative fields have been selected. The farm PH is located near Dinteloord N. B. on very heavy clay soil. The polder in which the farm is located has been under cultivation for some 300 years, and is by nature one of the very fertile sections of Holland. This polder was reclaimed from the sea and diked in about 300 years ago. Prior to B.D. management, this farm was intensively fertilized with commercial fertilizers, plus a reasonable amount of manure (10 tons farmyard manure/acre to sugar beets, once in a four to five year rotation). The crop rotation was: sugar beets, oats plus clover or alfalfa, clover or alfalfa, winter wheat (soft, red varieties), summer wheat or barley, caraway or flax, sugar beets or potatoes. Caraway or flax were grown because of their soil structure-improving quality. In more recent years, only flax has been used, which yielded regularly very well, was free of diseases, and paid very well. Instead of clover or alfalfa, other annual legume crops were also grown, such as field peas for seed and beans (small, brown). The ground water level was rather high and somewhat regulated by pumping. In general, dry years resulted in better crops than wet years. The rainfall is fairly evenly distributed over the years, with maxima during late fall, winter and spring. The yearly average is about 35-40 inches. The climate is fairly cool and moist.

The farm measured 125 acres; it had only some 15 acres of permanent pasture; livestock of 14 to 16 dairy cows (Holstein, pedigree), a corresponding amount of young animals, 1 bull. Some breeding of heavy Belgian draft horses was done because there were champion stallions in the neighborhood. It was a typical sugar beet and grain farm, diversified in a fashion, and with good crop levels, slightly above the average of the area. The conversion to the B.D. method started in 1928. Ever since then, only farmyard manure has been used, set up in piles and B.D.-treated. The practice of giving 10 tons of manure per acre (mixed and composted, from all sources) to sugar beets or potatoes was continued, but no commercial fertilizer was bought. The gain is therefore due to the improvement of the manure quality. It is quite obvious that the B.D. treatment of the manure avoids nitrogen losses and raises the fertilizer quality of the manure. The livestock was fed mainly from products of the farm and very little concentrated additional feed was bought. During the first ten years, while this author supervised the management, there were never more than 6 lbs. of concentrates fed to high producing dairy cows; on the average only 3 lbs. Since this farm was one of the earliest with B.D. management, considerable experience had to be acquired with regard to crop rotation and conversion; mistakes were made, and the first years were rough, with irregular yields. Only after the initial experiences was there a more stabilized situation. The soils were very heavy, requiring special skill in their cultivation so as to achieve a crumbly structure, especially in wet years. The compaction of the soil when harvesting sugar beets in a wet fall is a terrible handicap. In spite of the good results obtained recently, the problem of the physical structure and compaction is not yet entirely solved. Sugar beets, with an average of 16-18% sugar, are such a good cash crop that the management has not yet decided to give up their cultivation.

The two other farms, TL and TM, are on the island of Walcheren, only a few miles from the coastline. These are lighter soils, partially sandy humus, partially sandy loam, but a few fields of TL were extremely heavy clay and tight loam with poor drainage (TL-3). These two farms had the benefit of more legume crops, which always did well. TL had a typical grain rotation. Instead of sugar beets, fodder beets and mangels were occasionally grown with very satisfactory results.

Both farms were operated independently in the beginning, but after the World War II flood they were pooled together into one unit. The conversion of TL was started in 1930/31 and that of TM in 1934. Before the war, also a truck garden of 21 acres for vegetables and 2½ acres of greenhouses were maintained on TM. These were destroyed completely by the flood in 1945 and no attempt was made to rebuild them, except for one small house for table grapes. On TL there is also a bakery which produces from 7,000 to 10,000 loaves of bread per week from B.D. raised wheat — the famous Loverendale Whole Wheat Bread. There is also a grain mill, using old-fashioned grinding stones 4 feet in diameter.

The livestock intensity is similar to PH. The two farms together have about 204 acres of cropland and 50 acres of far away pastures (the latter not included in this report). Before conversion, they were average-yielding farms — nothing remarkable to report; in fact, TM which recently showed spectacular yields, was below average and a real Cinderella. However, it had never been misused for intensive production. The soils of TM were light, deep, sandy humus. The ground water level was and is high, but after the flood in 1945 better drainage and ditches improved the situation considerably. These farms could be considered typical of the old-fashioned diversified peasant farm. One reason for the spectacular yields recently obtained is certainly the fact that the very same peasant farm style management has been maintained.

It is this writer's opinion that, with regard to soil structure and profitable economy, as well as with regard to obtaining maximum yields at minimum cost, this type of management can still beat any streamlined grain factory. It is only necessary to maintain a suitable proportion between intensive grain land and legume growth, as well as pasture land, to produce enough manure and compost to become independent of additional fertilizer needs. Of course, even here one had to follow the modern trend of mechanization and reduced labor employment per acre, but on heavy wet soils, the old-fashioned, no longer possible, plowing and cultivation with horses, though slow, had its advantages over tractor compaction.

Before the war, these two farms were doing all right, but nothing unusual could be reported — just good average in tune with the fertility and yields of the area. Maybe it is important to mention, however, that even then, after conversion, no more commercial fertilizer was bought, and especially that no nitrogen was ever needed. The greenhouses grew excellent and healthy crops, with no sprays, pests or diseases whatsoever and no renewal of soil. These greenhouses were used mainly for tomatoes, cauliflower, cucumbers and table grapes; during the winter occasionally chrysanthemums and tulips (Darwin and others) for cut flowers were grown. These were shipped to England and were much liked because they remained fresh for two weeks in the flower shop. When the inflation of the English pound sterling and the depression occurred in 1934, we had about one million cut flowers ready for shipment and we took a terrible beating.

The great event on these two farms was the day the Dutch pierced the dikes toward the sea and flooded the island in order to chase out the German army of occupation. The sea water flooded the land entirely and it remained flooded for 15 months. Commutation from house to house was by boat; the tides moved in and out daily. No plant life whatsoever survived. All the trees and windbreaks which had been planted with great care and effort perished. After the land was dried and drained it showed a grey, spongy surface. It was thought that it would take at least ten years to reclaim it. For a while, nobody but Loverendale planted trees and shrubs again, and even in 1950 the area of these two farms could be spotted immediately because of the trees growing again, while otherwise one could gaze 15 miles in any one direction over plain flat land.

The recovery took only five years and thereafter the development of these fields began to show spectacular increases in yield, which were reported in BIO-DYNAMICS #59 (1). As it was, the flood had washed away the errors of the past, the influences of fertilizers, and an ideal humus structure could be developed in due time. Without the diligent care of M. Steyn, the present director of Loverendale, (who has been with the company almost 30 years, who grew up there, started as gardener apprentice and learned to know the soils and to grow vegetables and an orchard and who finally took over the entire management), and without the supervision and advice of Dr. Hans Heinze, with his many years of bio-dynamic farming consultation, all this would not have been possible. There was also a faithful and cooperative stock of local farm labor, some of whom lived on the farm and had cultivated the fields for 40 and more years and saw the previous as well as the new management. One of these old timers, very tight-lipped, was once asked, "What do you think now of bio-dynamic management?" "Well", he said hesitantly, after a few minutes' silence, "I see it grow".

After this description of the farm situation, we shall now discuss the results of the soil survey. There is first the somewhat startling discovery that all the soils had become alkaline. This is rather unusual, for the type of alluvial soils from river deposits of hundreds of years ago tend to be acid. But because these soils were reclaimed from the sea, they are penetrated by shells of crustaceæ, which also explains the high calcium content. Nevertheless, no alkaline or saline damages could be found, even though winds and storms blew a lot of seamist over the land because of the proximity to the coastline. Only in the market garden and greenhouses which had water sprinkling systems, did we notice an increase of chlorine to 0.1% (NaCl). We introduced and preferred, from then on, underground irrigation, and no more problems arose. The alkalinity is "biological", for all humus-forming organisms in compost and soil tend to produce an alkaline reaction. In fact, in bio-dynamic treatment of composts and manures, we try to stay away from acid humus because of its instability, its leaching out, and the danger of very dangerous "bog iron" (or a calcareous-iron-humus compound), which is very toxic to roots. The organic matter levels, according to our standards, with 2.5 to 3.0%, are moderately high. There is, however, a difference between the organic matter of PH and the two other farms, TL and TM. (See Table 1.)

PH is an old soil of hundreds of years of cultivation. PH 1 has been, as far back as we can ascertain, but at least for 50 years, permanent pasture. It shows, therefore, the very values of a fertility which has been preserved. In a way, this represents the standard reference situation against which losses or increases or maintenance can be measured. The two other soils of PH can be compared with this reference soil and tell of the still good but nevertheless reduced level because of intensive cropping.

The organic matter of TL and TM has been built up since

1945, for at that time the flood had destroyed all life. It is now very interesting to see two soils of TL (3 and 7) improved, while TL 12 declined. This field, after sods were plowed under, was intensively cropped and is apparently very sensitive to humus losses because of exposure. The reason for the drop in organic matter of TM 4 is entirely different. Here we have an orchard in good condition which, in recent years, because of the shade from the trees, was not well aerated and also did not receive enough compost.

The figures for nitrate, with a few exceptions, are moderate and show only insignificant fluctuation between 1951 and 1961. They are supposed to indicate nitrification and nitrate availability to roots. But there does not appear a relationship to the crop levels of the various fields or an explanation of the increase over the last 10 years. In fact, one field with 20 p.p.m. did not yield more or less than others with 36 p.p.m.

The figures for ammonia show a very slight increase. In bio-dynamic soils we usually find no free ammonia. We prefer well-aerated soils, for with them nitrate formation has a better chance. Ammonia shows up either after fresh manure has been applied or after the use of ammonia fertilizer. Neither reason applies here. Ammonia, under the management as it was, is a sign that excessive nitrogen may be present, so that under wet and somewhat anaerobic conditions ammonia "spills over".

It is for that reason — because the nitrate and ammonia levels did not show a relationship to the yields and manure application — that we decided to run tests for total nitrogen. These were done using a standard method (micro-Kjeldahl). The results were, to say the least, interesting and surprising. The total nitrogen content ranked between .18% and .48%, most frequently near .22%. In terms of lbs./acre, counting the 6″ deep topsoil as 2,000,000 lbs., this means between 3,600 and 9,600 lbs./acre. The highest value was found on the pasture which we know had been so used for at least 50 years, probably much longer. This soil we might consider the "reference" soil, not touched by plowing and harvesting and closest to a virgin condition. All other soils were more or less heavily used arable cropland. The original reference soil had a nitrogen content as one frequently finds in wet farmyard manure and garden- or farm-made composts. This total nitrogen is present in the organic matter of the soils, in the so-called humus, a stable humus, not humic acids or acid humus which can be washed out and would run off the field with every rain. The water coming out of the drain tiles and collecting in the ditches is clear; we might therefore call this humus unerodable. Much of this matter is present in the form of protein and other complex compounds of the living cells of soil organisms. Some of it is in form of the breakdown products, but the living process of nitrification and of weathering provides enough nitrogen in available and root-acceptable form, so that on these fields no nitrogen deficiencies show up and the phenomenon of tied down nitrogen (temporarily tied down, as it was) occurs only for short periods of very wet conditions. The yields reported in BIO-DYNAMICS #59 certainly do not indicate nitrogen deficiencies. This is a strong point for the efficiency of a properly applied B.D. treatment of manures, composts and soils — namely that for these no nitrogen problem exists. This experience we have had on many B.D. farms abroad as well as in this country. The point is to "grow" nitrogen; that is, to maintain such conditions that nitrogen fixation is a natural "crop" underneath the soil surface. "Feed your soil (3) and your soil will feed your plants" is a phrase from an article written by Lyle Wynd some years ago. The maintenance of such a soil life as will supply a sizable nitrogen reserve, made available at the growing period of crops, with a steady release, is one major aim and achievement with proper application of B.D. practices. On the farms about which we are reporting, no nitrogen fertilizer was bought during this observation period of 25 years. We do not deny the truth of the fact that nitrogen is a major fertilizer element for obtaining good crops and yields, but we just go about it in a different way than common agricultural thinking believes it must be done.

In literature and textbooks, one finds mentioned as a rule of thumb that usually 5% of the total organic matter of a soil (in lbs./acre) is present as nitrogen. Using this rule as a measure, we can calculate how many lbs./acre of nitrogen should or could be present in these soils of Loverendale. The table on nitrogen (Table 2), therefore, contains as a last figure the "theoretical" amount of nitrogen, which ranks, with one exception (TM 1) lower, and frequently much lower, than the actual findings; for instance, the "reference" soil had 9,600 lbs. of nitrogen per acre. According to its 4.3% organic matter, using the 5% rule, it would have 4,300 lbs./acre. Of great interest is that the orchard soil (TM 4) with its low organic matter of 1.8% should have, theoretically, 1,800 lbs. of nitrogen per acre but, in reality, has 4,000 lbs./acre. We see, therefore, in this and most other soils, that there is an abundant reserve and that these soils are really saturated with nitrogen, even under conditions where heavy cropping, including one year of sugar beets or potatoes, two to three years of grain, and a rest period of only two years of clover or alfalfa in the crop rotation, is maintained. This process of *growing* nitrogen makes it worth while using the B.D. method.

In discussing the soil analyses for available phosphate and potash and total phosphate and potash, the very same observation was made, namely, that these soils had, according to the common fertilizer concept, reasonably satisfactory amounts of available phosphate and potash per acre (see Table 3) but that the reserves in the form of total phosphate were, in most cases, more than ten times as much as the available figures in terms of lbs./acre. Total phosphate and potash were determined according to standard methods of analysis. In the case of potash, this is quite a tedious method. With regard to potash, the actual figures of available lbs./acre are sometimes not in any direct relationship to the actual total amount per acre. Our reference soil (PH 1), for instance, had a relatively low available potash (190 lbs./acre) but an extremely high reserve of 2.3% or 46,000 lbs./acre. Other soils (PH 4 and 5) had a reserve of 1.3% (26,000 lbs.), while another field of the same farm (PH 19 and 20) had 1.8% (36,000 lbs.) at the same level of 180 lbs./acre of available potash. Again, the point is that these soils were heavily cropped and that the task is to establish and maintain such biological conditions that one can draw on the reserves. No potash fertilizer was bought over the reported period of 25 years.

The question may be raised, how long will these reserves last and are there natural processes which may replenish these reserves. So far, the turning under or composting of crop residues and the manuring of the fields within the limits of crop rotation seemed to be satisfactory. So far, the maintenance of the organic and biological conditions helped in the skillful use of the reserves. Soils which were over-intensively used by grain cropping without rest periods showed lower reserves but were still abundantly provided with available and total potash. We know from experience that green crops especially, make heavy demands on potash, and we found elsewhere that one of the weak points of many organic farms with greenland management, alfalfa, grass and clover was that they were low in available potash. We are not dogmatic in this regard and would not refuse to apply supplementation where necessary, but we would prefer such supplementation by means of lasting resources as long as the natural biological process can make them available — for instance, by using certain potash-containing rock rather than by water soluble and therefore easily washed out salts. If necessary, we would not refuse potash-magnesia and/or potash rock (certain granites, for instance Hybro-Tite) which can be rendered available.

The same applies to phosphate. The rules are to avoid tying down. An alkaline rock phosphate applied to an alkaline soil will not become available unless there is such soil life or micro-organisms which can convert it. This problem, unfortunately, has not been investigated as yet. Easily available, acid phosphates are frequently tied down and become unavailable as soon as they hit the soil. Only 10% of these may remain usable on the average. Again, the biological condition of the soil decides which way the process will turn. With regard to phosphates, we see that most soils of this report were well provided with phosphate reserves and that 25 years of B.D. management has not yet exhausted them. On heavy clay soils under wet conditions, with occluded surfaces, we see that making phosphate available may be a problem. In order to work with and not against the biological-organic process, we feel it is preferable to enrich the manures and composts with natural phosphates. This has been done a few times on a few fields of TL by adding a small amount of phosphate to the barnyard manure and should definitely be done on PH 4 and 5, PH 19 and 20 and TL 3. It should be done in reasonable amounts, for instance 50 lbs. per ton of manure, but certainly not in any excessive amounts; that is, using just as much as the biological conditions allow it to "digest".

Little can be said in this report about calcium and magnesium, both of which seem to be present in abundant amounts, so that there is only the problem of rendering them available or exchangeable. It may be noteworthy that this goal has been reached in almost all the soils of Loverendale. It is also obvious that the high exchange figures obtained by 1961 express an optimum or stabilization rather than absolute values. A proportion of calcium to magnesium of 3:1 or 2:1 is considered to be well-balanced, so that no calcium damage will show up. Most of these soils are close to this balance. (See Table 4).

With regard to trace minerals, we did not find trace mineral deficiency symptoms in the leaves of plants. The analysis for available minerals shows that manganese seems to be somewhat of a problem, that is, apparently it is tied down. Boron is on the low edge, but alfalfa did not show leaf symptoms of its deficiency, and copper, though low, was abundantly provided.

Summarizing, it may be said that basically the soils of Loverendale did not fare badly over the period covered by the report. However, there was and still is the problem that the heavy clay soils are extremely sensitive to excess moisture and still offer problems of aeration and cultivation. Using the law of the minimum in a universal way, including all factors of life and growth and not only the limited N-P-K concept, it is this writer's opinion that structure and surface occlusion problems, as well as drainage and water circulation, could still be improved. These are the "minimum" requirements — that is, as regards physical conditions — to which attention needs to be paid. But this is a matter of soil management and crop rotation and not of fertilizer application. With regard to yield and utilization of reserves, the lighter soils responded much more quickly to treatment than the heavier soils.

Table 1. *Structure, Color, pH and Organic Matter.*

Farm & Field #		Structure and Color	pH 1951	pH 1961	Organic Matter % 1951	Organic Matter % 1961
TL	3	loamy, compact, clay light brown, heavy	7.9	7.8	2.7	3.4
	7	sandy loam, compact, gray	8.0	7.7	3.0	3.8
	12	loamy, medium heavy, compact, brown	7.9	7.8	4.2	1.9
TM	1	loamy, friable, grey-brown	7.9	7.7	—	3.7
	4	Boomgaard, clay, loamy, brown-grey	7.8	7.8	3.5	1.8
	6	loamy, compact, grey-brown	7.9	7.7	2.5	3.8
PH	4 & 5	loamy, friable, brown	—	7.8	—	2.7
	19 & 20	loamy, friable, brown	—	7.6	—	2.3
	1 pasture	sandy loam, compact, dark brown	—	7.7	—	4.3

Table 2. Nitrogen

Farm & Field #	Nitrate 1951	Nitrate 1961	Ammonia 1951	Ammonia 1961	Total Nitrogen 1961 %	Total Nitrogen 1961 lbs./acre	Nitrogen 1961 as 5% of O. M. in lbs./acre
TL 3	16	20	trace	3	.19	3800	3400
7	24	20	trace	3	.25	5000	3800
12	20	12	trace	3	.22	4400	1900
TM 1	16	16	trace	4	.18	3600	3700
4	32	40	trace	5	.20	4000	1800
6	35	56	trace	2	.24	4800	3800
PH 4 & 5	—	52	—	2	.22	4400	2700
19 & 20	—	36	—	3	.20	4000	2300
1 pasture	—	48	—	2	.48	9600	4300

Table 3. Phosphate and Potash

Farm & Field #	Available Phosphate—lbs./acre 1951	Available Phosphate—lbs./acre 1961	Total Phos. 1961 as P_2O_5 %	Total Phos. 1961 as P_2O_5 lbs./acre	Available Potash—lbs./acre 1951	Available Potash—lbs./acre 1961	Total Potash 1961 %	Total Potash 1961 lbs./acre
TL 3	175	200	.075	1500	350	200	1.45	29000
7	200	400+	.225	4500	350	190	1.24	24800
12	150	300+	.150	3000	180	220	1.60	32000
TM 1	—	400+	.175	3500	220	220	1.32	26000
4	200	400+	.150	3000	260	230	1.94	38800
6	200	300+	.200	4000	220	200	1.42	28400
PH 4 & 5	—	150	.100	2000	—	180	1.3	26000
19 & 20	—	150	.125	2500	—	180	1.8	36000
1 pasture	—	300	.325	6500	—	190	2.3	46000

Table 4. Exchange Calcium, Magnesium, Manganese, Boron, Copper

Farm & Field #	Calcium lbs./acre 1951	Calcium lbs./acre 1961	Magnesium lbs./acre 1951	Magnesium lbs./acre 1961	Manganese lbs./acre 1951	Manganese lbs./acre 1961	Boron p.p.m. 1961	Copper p.p.m. 1961
TL 3	4000	5600	300	1500	0	0	5	2
7	3500	5600	300	1500	0	low	4	2
12	1800	5600	350	1500	0	0	4	2
TM 1	—	4400	—	1500	0	trace	2	2
4	4000	5600	300	750	0	trace	2	2
6	3000	2800	trace	600	0	0	4	1
PH 4 & 5	—	5600	—	1700	0	trace	5	2
19 & 20	—	5600	—	1500	0	trace	4	2
1 pasture	—	5600	—	1500	0	0	6	2

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