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Raw Organic Matter Accumulations Under Various Systems of Culture

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The organic matter of soils is usually treated as a whole and such distinctions as may be made as to progress of decompostion have been based upon chemical relations such as the nitrogen-carbon ratio. Periods of wide ratio following the addition of quantities of fresh residues become more than temporary affairs under semiarid High Plains conditions, largely as a result of moisture relations. It is common to be able to identify remnants of crop residues in the soil the second and third seasons after the particular crop was grown, and a continuation of annually returning wheat or sorghum residues to the soil brings about a considerable accumulation of raw material which is present throughout the year. The amount of unassimilated material of this kind carried over from one crop year to another may depend upon variations of both crop yields, which govern the annual supplies, and seasonal conditions, which influence the rate of decomposition.

Inasmuch as the humus content of the soil is directly dependent upon the supply and assimilation of this raw organic matter, and because under the conditions described above it constitutes a considerable fraction of the total organic matter of the soil, an attempt has been made to investigate the factors of control and the significance of raw organic matter as a primary form.

Selected References

Indirectly related to the problem is that section of the literature which deals with the decomposition of residues—the physical, chemical and biological effects of fresh additions of organic matter. The following references indicate the variety of important effects depending on organic matter changes in the soil.

Starkey[8] noted that the decompostion of rye straw during its early stage depleted soil of soluble nitrogen. Similar results have been noted and commented upon by numerous other writers. The phenomena have been attributed to various causes, among which are: the competition of carbon oxidizing organisms for nitrates used in their growth; and the development of substances deleterious to nitrifying bacteria.

Tenney and Waksman[9] observed that, while a longer time was required for decomposition under anaerobic conditions, as much as 12 to 14 months was required for the decomposition of rye straw and corn stalks under aerobic conditions. The residue of decomposition contained crude protein.

Deturk[2] concluded that the effects of organic matter upon crop yields resulted largely from the decomposition processes of active organic matter rather than from the accumulation of inert residuum which accumulated in but small and difficultly measurable amounts.

Russell and Appleyard[6] observed that the decomposition of soil organic matter, as measured by bacterial counts, carbon dioxide evolution, and soil nitrate content, was arrested by temperatures of five degrees Centigrade and lower and by dry soil conditions. Under dry conditions a shower of rain gave a marked stimulation to the resumption of decomposition.

Alway and Neller[1] found from a field study of organic matter that a soil high in organic matter retained more moisture in the first foot during a cool wet summer; but in a dry summer smaller differences were noted in the moisture content of soils high and low in organic matter, and no advantage to crop production was claimed.

Shaw[7] determined that the condition of organic matter (either raw or decomposed) did not affect the marked relation between the amount of organic matter and the water holding capacity of soils.

Some observations throwing light on the length of time required for the decomposition of organic matter in High Plains soil have been made at the Panhandle (Oklahoma) Experiment Station.

The effects of residues upon nitrate formation have been indicated[3] in a recently reported study where it was shown that residues incorporated by plowing or listing apparently required about three years' time for decay to reach a nitrogen-carbon ratio at which maximum nitrate accumulation was possible. The residual effects of barnyard manure[4] were shown to be present four years or more after application.

Lastly, the examination of soils which have been cleanly cultivated for 30 months or more after the removal of the last crop revealed the presence, apparent to the naked eye, of undecayed vegetable particles in the soil.

Scope of Investigation

Attention is here directed not to total soil organic matter but to the unassimilated fraction which remains identifiable structurally as plant tissue and which is separable by physical means from the soil mass. Phases of this study embraced (1) the adoption of a method of observation, (2) a survey of the scale of variation existing under fluctuations of such factors as manner of cropping, harvest and tillage, and the seasonal climatic features, and finally (3) a determination of the moisture and fertility relations of raw organic matter in the soil with a view to governing and utilizing their effects for economic production.

The Physical Separation of Unassimilated Organic Matter From the Soil

The following suggested technic for separating unassimilated organic matter from the soil will readily be observed to draw the line of distinction between assimilated and unassimilated organic matter at the specific gravity of water. Only such particles are removed as retain sufficient cellular integrity to float on water.

The process of separating floatage is relatively simple, with the accuracy depending largely on dispersion of soil aggregates, complete separation of floating particles, the washing of same, and the accurate weighing of the separate. The first factor is dealt with by providing an adequate amount of agitation, the second by the successive separation of small portions of the sample, the third by a repetition of washing, and the fourth by guarding during weighing against electrification of the separate and tube in which it is contained.

Method

Air dried samples prepared and stored in bottles should be thoroughly remixed before sampling. Weigh 10 grams to .1 gram accuracy on a sheet of glazed paper. Pour approximately one-third of the quantity into a ¾-inch by 7-inch test tube. Fill with tap water to one and one-half inches of the mouth, stopper, shake steadily for one minute, invert at an angle of 45 degrees, and manipulate by half turns until the heavier particles of soil first settling out have been thoroughly agitated to liberate all the floatage. Let stand inverted until the upper portion of the suspension has begun to clear, then unstopper with the mouth immersed in a vessel containing six to eight inches of water. The tube should be held suspended a moment until the substance at the mouth comes out, then allowed to sink to the bottom for a sufficient time to permit all the floating particles to accumulate in a ring at the surface. When this is done, lift without agitating the floatage until the mouth is clear of the surface of water an instant, sufficient to let out a small quantity of water from the tube. Floatage which was disturbed or failed to adhere at the first ring may again be collected lower on the side of the tube in the same manner and the process repeated until all the floating particles adhere to the inside of the tube. The remaining water is then let out, the mouth of the tube wiped with a towel and a second third of the sample put in. Tap water is again added and the manipulation just described repeated, after which the remaining portion of the ten gram sample is added and treated in the same manner. All the separable floatage thus accumulated in the test tube is then washed twice by refilling with clear water or until the wash water becomes clear, the floating particles being collected in successive rings adhering to the side of the tube as the water is let out in the manner before described. When the tube has been washed clear of all but floating material it is dried in an oven at boiling temperature, cooled in a desiccator, and accurately weighed to the fourth decimal place without stopper. The floatage is removed from the tube with a test tube bristle brush. If electrification of the material occurs, the clean tube must be wiped with a very slightly damp towel, replaced in the desiccator to dry, and then weighed. Satisfactory checks can be obtained from homogeneous samples if the amount of floatage obtained exceeds .001 gram. When the quantity is smaller than this, additional checks must be run, since neither a larger tube nor larger sample can be used except at a risk of more difficult collection of floatage and less complete separation from the heavier soil particles. Express unassimilated organic matter in parts per million.

Error of Determination. The experimental error involved in the process described was determined for a sample of silt loam topsoil relatively low in unassimilated organic matter. A series of 20 determinations showed the accuracy was considerably increased by separating the floatage in three portions rather than placing the entire 10 grams of soil in the tube at one time. The amount of floatage was also increased. Where a single separation was made, a mean of 215 parts per million with a standard deviation of 75 was obtained. Where the same sized sample was separated in three successive portions, as described in the above outlined method, 229 parts per million with a standard deviation of 42 were shown. Additional refinements of this method might be suggested, although it is questionable whether more time could be profitably spent making such an estimation except possibly in soils where the amount of raw organic matter present varied within narrow extremes and persisted for shorter periods of time. Under High Plains conditions an error of 100 parts per million would be permissible and still allow significant readings to be made, since the observed range of values fluctuated between 50 parts per million and 1750 parts per million.

Character of Material Separated

In order to check up on the composition of the unassimilated organic matter separated by the above method, certain analyses were made comparing it with wheat straw harvested from the same series of plots.

Calculated to a moisture free basis, the raw organic matter contained 1.36 percent nitrogen, 45.13 percent carbon and 1.78 percent ash. The wheat straw contained .55 percent nitrogen and 8.00 percent ash. A carbon analysis of this particular sample of wheat straw was not available. Estimates from other analyses, however, would place the figure for carbon at approximately 38.00 percent.

A difference which might not be expected considering the derivation of the two materials was that shown in the ash content. Probable explanations of the comparison shown are that the high ash from wheat straw came partly from dust particles collected during field exposure and that the low ash of the raw organic matter was representative of material which had been thoroughly washed a number of times.

The other relations shown correspond to what might be expected from the difference in exposure to weather which the two materials had undergone.

Experimental Data

Determinations by the above method have been made annually on 22 plots variously cropped over a period of nine years at the Panhandle Agricultural Experiment Station, Goodwell, Oklahoma. Samples were obtained each year early in January between growing seasons, and consisted of composites of from six to fifteen tube cores per plot, 0 inch to 6 inches deep. Particular care was exercised in eliminating surface trash. The samples were air dried immediately in the laboratory and pulverized to pass a 20-mesh sieve, in which condition they were stored in bottles. During storage they had an average moisture content of from two to three percent.

The series of plots, 1303 to 1324, inclusive, has been cropped under schedules designed to provide suitable variables to study soil moisture behavior. Table 1 shows a record of the cropping by years, with the annual rainfall and average yields of wheat and sorghum indicated below. Table 2 gives the raw organic matter determinations following the cropping season in each instance, the determination being dated January of the following year. For example, the amount of raw organic matter carried over from the cropping season of 1926 as shown in Table 1 will be found under date of January 1927 in Table 2. The amount and distribution of rainfall, duration of cropping periods, and the yield of crops satisfactorily explain the general trends of rise and fall in unassimilated residues observed.

Relation of Rainfall to Residue Accumulation

Reference to the records of plots continuously cropped, such as 1303 and 1311 in wheat (see Table 2) and 1323 and 1324 in sudan grass, on which residues were returned each year will give some idea of the behavior of individual plots under fluctuating seasonal conditions. The annual series average at the foot of Table 2 follows the same trend.

Since all these plots started the experiment with somewhat less organic matter than the normal level which continuous cropping seemed capable of maintaining, a gradual rise was naturally expected. However, in January 1927 a rather sharp increase was noted which can be traced to the shortage of rainfall which began immediately after wheat harvest in 1926. Similarly the drop noticed at the end of the following year was in part due to a favorable distribution of rainfall during the summer and fall of 1927. The heavy yields of 1928 and 1929 again built up a surplus accumulation encouraged by the rainfall distribution of 1930 in which seven months were noticeably deficient in rainfall. Crop yields of 1930 were small and consequently the amount of residues was smaller than usual. Furthermore, the distribution of rainfall during 1931, though the total amount was not excessive, provided a long season favorable to the decay of organic matter. The result was that in January 1932 another marked decline occurred in the amount of raw organic matter carried over.

Effects of Cropping and Culture on Raw Organic Matter Accumulation

By observing individual plots in the wheat fallow systems where wheat has been introduced at varying intervals, it will be noted that increases in unassimilated residue showed up after cropping at intervals of six and eighteen months, the amount of increase depending usually upon the current moisture conditions and the size of crop.

When the plots are grouped according to various cropping methods, the average levels of raw organic matter surpluses maintained are indicated as in Table 3. This, of course, follows the expectation that the greatest surpluses were produced by the continuous production of closely spaced crops.

TABLE 1.—Cropping Schedule with Average Rainfall and Yield Data, 1923-31, Inclusive

Plot No.	1923	1924	1925	1926	1927	1928	1929	1930	1931
1303	Fallow	Wheat	Wheat F.	Wheat	Wheat F.	Wheat	Wheat	Wheat F.	Wheat
1304	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow
1305	Fallow	Fallow	Wheat F.	Fallow	Wheat F.	Fallow	Wheat	Fallow	Wheat
1306	Fallow	Fallow	Wheat F.	Fallow	Fallow	Wheat	Fallow	Fallow	Wheat
1307	Fallow	Fallow	Fallow	Wheat	Fallow	Fallow	Wheat	Fallow	Fallow
1308	Milo	Wheat	Fallow	Fallow	Wheat F.	Fallow	Fallow	Wheat	Fallow
1309	Milo	Weed M.	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow
1310	Milo	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow
1311	Milo	Wheat	Wheat F.	Wheat	Wheat F.	Wheat	Wheat	Wheat F.	Wheat
1312	Milo	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat	Fallow
1313	Milo	Fallow	Wheat F.	Fallow	Wheat F.	Fallow	Wheat	Fallow	Wheat
1314	Milo	Fallow	Wheat F.	Fallow	Fallow	Wheat	Fallow	Fallow	Wheat
1315	Milo	Fallow	Fallow	Wheat	Fallow	Fallow	Wheat	Fallow	Fallow
1316	Milo	Wheat	Fallow	Fallow	Wheat F.	Fallow	Fallow	Wheat	Fallow
1317	Milo	Weed M.	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow
1318	Milo	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow
1319	Milo	Milo 3½*	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½
1320	Milo	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7
1321	Milo	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½	Milo 3½
1322	Milo	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7	Milo 7
1323	Milo	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan
1324	Milo	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan	Sudan
Av. Rain-fall	24.12	12.13	15.93	17.28	16.34	24.30	18.37	18.53	16.18
Av. Total Yield Wheat		3285	.....	4740	— —	5306	3313	1280	3691
Av. Grain Yield Milo	1200	1093	1165	874	1376	1143	1207	1678	1020
Av. Total Yield Sudan		1295	1754	2850	4042	2432	1419	1710	584

"F." indicates crop failure.
"M" indicates manure crop.
*Figures indicate spacing of rows (in feet).

TABLE 2.—Raw Organic Matter Accumulations in the Topsoil of 22 Plots. 1924-32, Inclusive.

Plot No.	P.P.M. of Raw Organic Matter in Topsoil, 0"-6", Sampled in January									
	1924	1925	1926	1927	1928	1929	1930	1931	1932	Av.
1303	500	475	825	1225	700	625	1050	1425	800	847.22
1304	600	650	1050	1200	525	550	400	950	300	691.66
1305	675	575	675	650	450	50	450	1025	560	567.77
1306	800	625	775	950	450	275	525	1050	350	644.44
1307	750	675	600	1225	575	475	350	1000	130	642.22
1308	775	475	675	775	450	150	200	650	110	473.33
1309	800	525	650	675	350	225	275	250	80	425.55
1310	850	525	450	525	175	200	375	575	100	419.44
1311	850	875	975	1200	1025	1025	1025	1275	525	975.00
1312	850	875	1050	1450	1200	1150	1200	1425	210	1045.55
1313	625	350	525	350	500	300	575	1100	555	542.22
1314	625	375	425	500	225	550	300	1050	840	543.33
1315	700	325	250	600	675	250	400	750	65	446.11
1316	625	300	175	375	325	750	225	225	130	347.77
1317	625	525	500	525	150	125	75	275	110	323.33
1318	375	75	100	425	200	325	125	250	15	210.00
1319	625	575	975	1000	1025	550	800	575	375	722.22
1320	450	650	450	925	225	150	150	275	215	387.77
1321	625	875	625	875	550	625	425	275	170	560.55
1322	625	250	425	650	325	225	400	125	195	357.77
1323	400	475	850	725	1250	700	800	1075	405	742.22
1324	400	1050	1075	1550	1050	950	1275	1750	545	1071.66
Av.	643.2	550.0	640.9	825.2	563.6	464.8	518.2	788.6	308.4	

TABLE 3.—Average Level of Raw Organic Matter Maintained by Different Cropping Systems

Cropping	Raw Organic Matter (P.P.M. of Topsoil 0"-6")
Continuous wheat	911.1
Continuous sudan grass	906.9
Alternate wheat and fallow	686.8
Continuous 3½' Milo	641.4
Fallow, fallow, wheat	516.2
Continuous 7' milo	372.8
Continuous fallow	344.6

Effects of Tillage on Raw Organic Matter Accumulation

All comparisons of listing and plowing with only shallow preparation show more crude material present in the surface 6 inches of soil where the deeper tillage has been practiced. This appears to be a result of the deeper incorporation of aerial residues by turning under, thus increasing the area of tillage, and by the elimination of surface waste rising largely from the blowing away of the finer particles.

In the comparison of plowing and listing there appears to be two conflicting factors which must strike a balance in determining the accumulation of residues. Plowing more promptly and completely takes in the surface residues. Although the incorporation by listing is a bit tardy at the outset, the continued lister cultivation seems to be capable of reducing the residues to a small quantity. Level tillage hastens the start of decay but does not carry it to the extreme observed under listing. Where continuous fallow was begun with equal supplies of residues, listing has reduced the unassimilated portion to a very small amount; while the plots continuously fallowed for seven years by level methods of tillage still contain as much raw organic matter as do soils continuously cropped through the same period with wide-spaced milo.

Assuming that the rate of nitrification rises in direct proportion to the disappearance of residues, the effect of listing upon bacterial activity as previously pointed out[3] is hereby confirmed. The progress of nitrate formation was shown to be arrested temporarily by listing and later greatly accelerated when normal moisture relations were re-established.

Relation of Raw Organic Matter to Nitrates Present

When all crops are grouped together the correlation between raw organic residues and nitrates was $-.2030 \pm .05$. Adjusting both values to the annual group mean as 100 percent, thus eliminating the effect of high and low seasonal levels, raises this correlation to $-.2353 \pm .04$, not a very substantial improvement. These correlations are of rather doubtful significance, the nitrate level being more often affected by the forces of removal than by those causing variation in rate of formation, in a group where seasonal variations are admitted.

However, when the data are grouped as in Table 4, based upon the period averages for each system of culture, the following correlations are observed:

Raw organic matter to nitrate nitrogen $-.4264 \pm .14$.

Wheat and fallow subgroup, raw organic matter to nitrate nitrogen $-.6060 \pm .15$.

Sorghum subgroup, raw organic matter to nitrate nitrogen $-.8332 \pm .08$.

There appears to be a considerable difference in the rate of decay of wheat and sorghum residues as indicated by the nitrate relations. The presence of sorghum residues in the soil exhibits a somewhat closer negative relation to nitrates than that of wheat residues in equal quantity, the mean raw organic matter in the fallow wheat subgroup being 641 parts per million while that of the sorghum subgroup was 680 parts per million.

It may be a question whether organic bodies which have not reached a state of physical disintegration are in reality an integral part of the chemical system of the soil. It seems certain that they have not as yet had much influence upon the rapid increase of bacterial population or they could not have retained their structure. On the other hand, there must undoubtedly be some relation between the amount of unincorporated material present and the amount of organic matter in advancing stages of decay, because the latter must depend upon the former for replenishment. This sort of reasoning would explain the low correlation observed between raw organic matter and nitrates when individual yearly fluctuations are calculated. The closer correlations were observed when 7- and 8-year period averages were taken to represent the various cropping systems.

Estimated Rate of Disappearance of Wheat Residues

The cropping schedule involving wheat and summer fallow presents an opportunity for 16 or more observations for each of seven different combinations with the preceding four-year period, as shown in Table 5. The mean value observed in continuously fallowed plots of 344.5 parts per million was deducted from each of the means representing conditions following the introduction of wheat crops, and the remainder shown under the column "increase from crop" was credited to the crop residue.

A calculation based on these data was made to determine (by means of the algebraic solution of the equations thus provided) the average amount of raw organic matter left over from each of the previous four crops. Four primary equations were found to be available for each value, care being taken to use each one of the original equations an equal number of times in

TABLE 4.—Average Raw Organic Matter Present in January Under Various Systems of Culture, 1924-32

Plots		Period of Observation (Years)	Raw Organic Matter in Topsoil (P.P.M.)	Nitrate Nitrogen (P.P.M.) *
3	Continuous wheat; plowed	9	847.2	8.39
4-5	Alternate fallow and wheat; plowed	9	629.6	13.85
6-7-8	Fallow, fallow, wheat; plowed	9	586.6	12.13
11	Continuous wheat; listed	9	975.0	3.77
12-13	Alternate fallow and wheat; listed	9	793.8	6.95
14-15-16	Fallow, fallow, wheat; listed	9	445.7	7.74
9-10	Continuous fallow; plowed	9	422.4	12.71
17-18	Continuous fallow; listed	9	266.6	11.73
19	Continuous 3½' milo; fall lstd	9	722.2	3.44
21	Continuous 3½' milo; shallow preparation only	9	560.5	2.82
20	Continuous 7' milo; fall listed	9	387.7	5.01
22	Continuous 7' milo; shallow preparation only	9	357.7	3.27
24	Continuous 16" sudan; fall plowed	9	1071.6	1.62
23	Continuous 16" sudan; shallow preparation only	9	742.2	1.82

*Period of observation 7 and 8 years only.

TABLE 5.—Wheat Residue Combinations Represented in Field Plots at Goodwell, Oklahoma

No. of Observations Averaged	Residue Fractions Represented	Raw Organic Matter (P.P.M.)	Increase from Crop (P.P.M.)
18	a+b+c+d	911.1	566.6
18	b+d	654.7	312.2
18	a+c	768.8	424.4
16	a+d	513.5	168.9
20	b	557.0	212.5
18	c	473.3	128.8
36	Continuous Fallow Base Level	344.5	0.0

a=Unassimilated residues accrued in topsoil 6 months after harvest.
b=Unassimilated residues accrued in topsoil 18 months after harvest.
c=Unassimilated residues accrued in topsoil 30 months after harvest.
d=Unassimilated residues accrued in topsoil 42 months after harvest.
Base Level=Average unassimilated organic matter found in soils continuously fallowed, presumably accruing from weed residues.

the solution. The four values obtained were then averaged with the following result:

The base level or quantity found to be present independent of previous cropping amounted to 344.5 parts per million. It was derived presumably from weed growths. Derived from the immediately preceding crop an average of 182.4 parts per million was indicated; from the second preceding crop 240.7 parts per million; from the third, 157.0 parts per million; and from the fourth, 14.4 parts per million. These calculations substantiate the ob-

TABLE 6.—Calculated and Observed Raw Organic Matter Contents for Various Wheat Cropping Combinations

TYPE OF CROPPING				Calculated P.P.M.	Observed P.P.M.
1st year	2nd year	3rd year	4th year		
Fallow	Fallow	Fallow	Fallow	344.5	344.5
Wheat	Fallow	Fallow	Fallow	358.9	----
Fallow	Wheat	Fallow	Fallow	501.5	473.3
Fallow	Fallow	Wheat	Fallow	585.2	557.0
Fallow	Fallow	Fallow	Wheat	526.9	----
Wheat	Fallow	Fallow	Wheat	541.3	513.4
Wheat	Wheat	Fallow	Fallow	515.9	----
Fallow	Wheat	Wheat	Fallow	742.2	----
Fallow	Fallow	Wheat	Wheat	767.6	----
Wheat	Fallow	Wheat	Fallow	599.6	654.7
Fallow	Wheat	Fallow	Wheat	683.9	768.8
Wheat	Wheat	Wheat	Fallow	756.6	----
Wheat	Wheat	Fallow	Wheat	698.3	----
Wheat	Fallow	Wheat	Wheat	767.6	----
Fallow	Wheat	Wheat	Wheat	924.6	----
Wheat	Wheat	Wheat	Wheat	939.0	911.1

servations[3] previously made that where land was taken out of cultivation and continuously fallowed for a period of years a point was reached after the third or fourth year when nitrate formation was reduced for the want of raw material. The figures obtained would indicate that disappearance during the first year was replaced by further additions of surface residues which had not been returned to the 6" soil section at the time of the first observation. In following the records of fallow cropping schedules where two years of fallow intervene between crops of wheat, it was frequently observed that the quantity found eighteen months from harvest was greater than that found six months from harvest. This might be expected from the fact that many of the plots so cropped were permitted to go through the first fall and winter with the stubble standing, being plowed or listed down the following spring. The disappearance during the second year amounted to 83.7 parts per million and during the third year to 129.4 parts per million, which left on hand in separable form only 14.4 parts per million of the residue from a crop grown three years previously.

Where these values are used to construct a theoretical table embracing all combinations of wheat and fallow cropping during a four-year period as shown in Table 6, approximate expectations of the amount of unassimilated residues may be estimated. The last column of Table 6 shows the actual amounts found for such crop combinations as were observed in the field, and the average deviation from the calculated amount was 42 parts per million. This deviation is the same as that observed in a series of tests on different soil to determine the accuracy of the method of separation and indicates that the total error observed was due to laboratory technic rather than an insufficiency of the number of field samples required to give a correct mean.

Summary

A study was made of the accumulation under various cropping conditions of unassimilated organic matter in heavy silt loam soil at Goodwell, Oklahoma. Determinations were made by a flotation method on the surface six inches of soil for 22 plots covering a period of nine years. Amounts observed ranged from approximately 100 pounds per acre to as much as 3000 pounds per acre.

Close drilled crops, affording quantities of straw or stubble returned to the soil as residues, maintained the greater quantities of raw material. The surpluses left from wide spaced sorghum crops were no greater than those provided by such small weed growths as were permitted on continuously fallowed plots. The more marked fluctuations appeared to be the results of variations in rainfall quantity and distribution affecting the rate of decay. Maximum increases of raw organic matter following a wheat crop appeared at from six to eighteen months after harvest, depending on the time the stubble was turned under.

The rate of disappearance of wheat residues after eighteen months was estimated to average 83.7 parts per million on a basis of dry soil during the first twelve months, and 129.4 parts per million during the next twelve months, which left in separable form only 14.4 parts per million of the residue from a crop grown three years previously.

The manner of tillage seemed to have some influence on the rate of decomposition. The disappearance was slower at the start under listing than under plowing, but was greatly accelerated during the latter period and in the end reduced the surplus of raw material to the lowest point.

The correlation of average raw organic matter accumulations with average nitrate nitrogen accumulations under various cropping plans showed significant negative relations, but the annual fluctuation of nitrate nitrogen apppeared to be governed by some more strongly related factor such as movement of soil moisture.

Evident means of controlling the amount of excess organic matter pointed to the removal of surface residue, the time and manner of turning under residues, and the selection or spacing of crops.

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