THE MICRO-ORGANISMS IN PROFILES OF CERTAIN VIRGIN SOILS IN MANITOBA.

A THESIS

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THE MICRO-ORGANISMS IN PROFILES OF CERTAIN VIRGIN SOILS IN MANITOBA.

PART I.

NUMBERS OF MICRO-ORGANISMS.

INTRODUCTION AND HISTORICAL.

The physical and chemical features of various horizons in typical soil profiles have been considered by many investigators but little relating the activities of micro-organisms to the properties and processes observed is on record.

The population of micro-organisms of the soil horizon probably is a factor in producing the definite physical and chemical characteristics of the horizon. A systematic study of the micro-organisms in relation to the accepted horizons of various soil types may furnish results of great value to the edaphologist in explaining phenomena not well understood and of great importance to agriculture in general.

REVIEW OF LITERATURE.

Brown and Benton (3) made microbiological studies of some typical Iowa soil profiles. After reviewing the

literature on the numbers of micro-organisms in soils at various depths, they present careful descriptions of 39 soil profiles, recording the per cent of moisture and the numbers of bacteria, actinomycetes and fungi in each horizon. They report the largest numbers of bacteria and actinomycetes in the A1 or A2 horizons and the largest numbers of fungi sometimes in the A3 horizons. The most striking decreases occurred from the A3 to the B horizons although further decreases in each successive horizon were noted. Fungi decreased relatively less in numbers than actinomycetes and actinomycetes less than bacteria. Variation in moisture content seemed to have no definite relationship to the numbers of micro-organisms studied, especially in the lower horizons. A seasonal effect on numbers was noted although this was confined chiefly to the A1, A2 and A3 horizons. In some cases soil type differences were reflected in the numbers of micro-organisms in the various horizons. Organic matter, as noted by color, was reported to be the characteristic related most significantly to counts. Little relationship between variations in conditions in the subsoil and counts of micro-organisms was apparent, although more bacteria and actinomycetes were found in the subsoil of loess type than in those of drift origin.

McKibbin and Gray (21) studying chemical and microbiological factors in Quebec soil noted that microbiological activity is dependent to some extent on the amount of water present in the soil. They considered that soil type has a greater influence on the numbers of micro-organ-

isms than season. Later (15) in a study of podzol soils they submitted evidence to show that plate counts of bacteria as well as microbiological activity, as measured by carbon dioxide production and ammonification of urea, appear to be controlled by the organic matter relations of the well differentiated horizons.

Waksman and Purvis (31) determined the numbers of micro-organisms in Highmoor and Lowmoor peat profiles in New Jersey. In their conclusions they noted that the sphagnum layer of Highmoor soils contains relatively few bacteria, but below the sphagnum layer, or as soon as the sedimentary layers of the peat are reached there is a great increase in the number of bacteria. In the case of fungi a rapid decrease in numbers with the depth was noted.

Several workers have reported on micro-organisms at different depths in the soil, without correlating depth and soil horizon.

PROBLEM.

This report represents a continuation of a previous work (4) on the identity, prevalence and significance of fungi found in Manitoba surface soils. It covers an investigation of the micro-organisms in detail and of the moisture, organic matter content and pH reaction of the various horizons in 12 profiles representing 5 distinct virgin soils in Manitoba in the hope of adding information to the question of a distinctive microbiological population in morphologically distinguishable horizons.

METHODS OF SAMPLING AND ANALYZING.

A pit was dug in a representative area of each soil and blocks of soil about 8 inches (20 c.m.) square were cut from the vertical side showing characteristic horizons. The profile thus obtained in successive layers was wrapped in heavy paper for transportation to the laboratory. Field notes on the depth of the various horizons and their descriptions, temperature in each horizon, root development and native flora were recorded. In the laboratory a portion was cut from each horizon for moisture determination and the remains of the block rewrapped and held in a cool basement until the following day when microbiological analyses were made on a moisture free basis, using recognized bacteriological technique for diluting and counting (30) (6).

MICROBIOLOGICAL TECHNIQUE.

1. Brown's Sodium Albuminate Agar, medium 5, (13) was used for the growth of bacteria and actinomycetes. Plates were poured in two dilutions in duplicate and were incubated for 14 days at 26 to 28° C.

2. Waksman's Glucose peptone agar, medium 18, (13) adjusted to about pH 3.5 and medium 16, Czapek's agar (13) adjusted to pH 3.5 were used for fungi. Duplicate plates in two dilutions of each medium were incubated for 14 days at 25° C. The count recorded is the average of the 4 plates in the dilution the best adapted for counting. An extra set of plates representing lower dilutions of samples re-

ported in the latter part of this work, was incubated at 37° C.

3. The above two media were used also for culturing fungi anaerobically. Lower dilutions were plated and incubated for 4 days at about 25° C. in a CO_2 chamber. The CO_2 was generated by a Kipp generator and fed into the bottom of the air tight cylinder until a positive test for CO_2, using $Ca(OH)_2$ as an indicator, was obtained on the gas forced out of the top opening.

4. Ashby's Mannitol Phosphate Agar, medium 41 (13) was used for myxomycetes. The plates were poured in duplicate and incubated at 16 - 18° C. for 3 - 4 weeks.

5. Winogradsky's Glucose Peptone Solution, medium 12, (13) was used for anaerobic bacteria. The test tubes were incubated anaerobically in a Nobbe jar and evidence of the presence of bacteria was checked by microscopic examination in a water mount after 7 days incubation at room temperature. The reciprocal of the highest dilution showing bacteria is recorded as the count.

6. Hay infusion, medium 38, (13) was used for protozoa. After incubating for 2 - 3 weeks at room temperature the tubes were examined microscopically and the count of protozoa recorded as in the case of anaerobic bacteria.

7. Ditner's Calcium Nitrate Solution, medium 42, (13) was used for algae. The tubes were incubated in a sunny window for 3 weeks and the count recorded after macroscopical examination.

PHYSICAL AND CHEMICAL SOIL ANALYSES.

1. The per cent of soil organic matter was determined by Tiurin's volumetric method using Ischerekoff's coefficient for organic matter (29). The method was modified slightly: 25 ml. of 0.2 N Chromic acid were used instead of 50 ml. After boiling, the solution was made up to 250 ml. with distilled water. One hundred ml. of the latter were titrated against Mohre's solution. The results were multiplied by 2.5 and the per cent expressed on the moisture free basis.

2. The hydrogen ion concentration was measured by a Leed's and Northrup's potentiometer, using a quinhydrone electrode with a saturated calomel cell (2) (3).

3. The total moisture was determined by the oven method using a 50 gram sample. The results are expressed as per cent of the moisture free samples.

4. The moisture equivalent was determined by the method outlined by Brigs and McLane (7) and the hygroscopic and wilting coefficients calculated by Alway and Russel's method (1).

THE SOILS STUDIED.

The soils reported on in this investigation are classified and described according to Nikiforoff's scheme of soil classification which was modified by Ellis for Manitoba soil surveys (12). They represent five different soils.

SOIL I.

Profile 1.

Profile 1 was taken from the meadow prairie phase of

of the phyto-hydromorphic associate of the Fort Garry association in the Red River Valley combination in the chernozem zone. The area sampled is located at 49° 60' north latitude and 97° 30' west longitude, about three miles west of the Pembina highway and two miles south of the city of Winnipeg.

The parent material is alluvium and shallow lake deposit laid over the deep laminated lacustrian clay of Lake Agassiz.

The topography of the area is level and the precipitation water collects in the low lying areas. The microrelief of the region is hummocky, the hummocks being 3 - 5 feet in diameter and 4 - 6 inches high. The pit for sampling was dug through the diameter of the hummock and the profile samples were obtained below the centre of the hummock.

Ellis (11) has reported on the prevailing climatic conditions in this area in relation to soil phenomena, presenting the monthly rainfall and maximum, minimum and mean monthly temperatures during the growing season annually at Winnipeg for more than 50 years previous to 1928. During the months November to March the soil is frozen. The averages of the mean monthly temperatures during the growing season for the 53 year period 1875 - 1927 were as follows:- April 38.01, May 51.98, June 62.17, July 66.43, August 63.53, September 53.97 and October 41.01° Fahrenheit. The winter season precipitation, principally snow, is light, having varied in the period 1875 - 1927 from 1.96 inches (recorded as water) in 1912 to 8.75 inches in 1882. The mean rainfall

for April to October for the period 1872 - 1927 was 16.15 inches. For the year 1933 the monthly precipitation and maximum, minimum and mean temperature at Winnipeg were as follows:-

Month	Temperature in Deg. Fahrenheit.			Precipitation in inches.		
	Max.	Min.	Mean	Snow	Rain	Total
Jan.	33.4	-30.6	2.3	10.4	-	1.04
Feb.	39.1	-42.0	-1.9	6.1	-	0.61
Mar.	48.4	-18.8	17.1	2.7	0.20	0.47
April	72.2	-13.8	36.9	7.8	0.20	0.98
May	84.0	27.0	54.7	-	5.27	5.27
June	96.8	35.0	68.0	-	0.97	0.97
July	91.2	46.6	69.1	-	1.61	1.61
Aug.	93.2	38.2	66.7	-	3.63	3.63
Sept.	79.0	31.8	56.6	-	2.69	2.69
Oct.	72.8	13.6	36.3	6.6	0.01	0.67
Nov.	40.2	-16.2	17.5	17.2	-	1.72
Dec.	35.0	-42.4	-4.6	15.7	-	1.57
			Total	66.5	14.58	21.23

The vegetative cover consists of a solid sod of the following grasses: Poa pratensis, Poa compressa, Agropyron repens, Agropyron tenerum mixed with Grindelia squarrosa, Argentina anserina, Aster multiflorus, Symphoricarpos occidentalis. Species of Spartina, Antennaria and Solidago and, in patches, Salix spp. and Populus tremuloides dot the surface in low lying areas.

Ants are active on some of the hummocks.

Description of Profile 1.

A1 horizon (0-2.5 inches) consists of a well decomposed dark brown organic material mixed with black silty-clay, and a well developed mat of roots. This horizon can

be easily separated from A2.

A2 (2.5 - 5 inches) consists of black clay in closely packed, hard, dull faced granules.

B1 (5 - 11 inches) silty clay, gray in color, streaked vertically with darker colors. The horizon has a weakly developed structure, being crumbly, friable and highly calcareous. Horizon B1 slowly grades into B2; the line of demarcation is hard to discern. Roots are not as abundant as in A2.

B2 (11 - 19 inches) very fine sandy clay, buff colored, crumbles easily. Specks of iron accumulation are common. Roots are rare. Horizon B2 is hard to separate from the parent material.

C (19 - 31 inches) light buff colored clay - very fine sand, thin layers of gray clay richly speckled with iron accumulation. Pin-holes of decayed roots are quite numerous. This profile represents a normal meadow prairie soil. The tongued intrusions at the ends of the hummocks are due to the cracking of the soil, which occurs during the dry periods of the season, and seepage of surface soil through these cracks into the subsoil (11).

Profile 2.

Profile 2 is a duplicate of profile 1, obtained 13 days later by removing the loose earth and cutting back the face of the pit about 1 foot before sampling.

Profile 3.

Profile 3 represents the same type of soil as profile

1. It is located in the zone of transition of the Red River Valley association into the Fort Garry association. The islands of alkalinized Red River and Fort Garry meadow prairie soils are intermixed in this area.

The location of profile 3 is about 2 miles south east of the area of profile 1, about 100 yards west of Pembina highway and about 300 yards north east from the electric power line. The surface of this area is less hummocky and the hummocks are larger in diameter and lower in height. Vegetation is the same as in the case of profile 1. The samples were obtained June the 20th.

Profile 4.

Profile 4 is a duplicate of profile 1. The pit was dug about 25 yards north east from profile 1. The samples were obtained September the 21st.

SOIL II.

Profile 5.

Profile 5 was taken from the alkalinized phase of the phyto-hydromorphic associate of the Red River association in the Red River Valley combination in the chernozem zone. The parent material is lacustrian clay of Lake Agassiz. The topography is slightly hummocky. The location is about 50 yards north of profile 3. The climate and vegetation are the same as in the case of profile 1.

Description of profile 5.

A (0 - 3 inches) black clay mixed with organic debris,

structureless, filled with grass root mat.

A - B (3 - 10 inches) dark brown clay, irregular and slightly angular granules up to wheat size. Roots are developed very well.

B - C (10 - 40 inches) grayish brown clay, forming columns about 7X3 inches in size. Roots are poorly developed.

C1 (40 - 71 inches) olive gray clay, slightly mottled with yellowish gray specks. Only a few roots were observed in this horizon.

C2 (71 - 76 inches). This is a thin layer of buff colored material of silty clay, which is a characteristic factor of Red River associates.

SOIL III.

Profile 6.

Profile 6 was taken from the wooded phase of the phytomorphic associate of the Fort Garry association in the Red River Valley combination in the chernozem zone.

The location of the profile is 49° 70' north latitude and 97° 30' west longitude, about 6 miles north of profile 1 and about 1 mile west of the Assiniboine River.

The climate is the same as in case of soil I.

The vegetation consists chiefly of poplars, Populus tremuloides and Populus balsamifera, with clumps of oaks, Quercus macrocarpa, up to about 7 inches in diameter, and underbrush of Corylus americana, Corylus rostrata, Viburnum pubescens, Crataegus coccinea, Symphoricarpus occidentalis, Pyrola asarifolia, Aralia nudicales, Carex stenophyla, Unifolium canadense.

Earthworms appear to be quite numerous.

Description of Profile 6.

Ao (0 - 1 inches) leaf mat well decomposed, penetrated by rhizomorphs of fungi.

A1 (1 - 4 inches) dark fine sandy clay; powdery with buck-wheat size granules, mixed with finely divided organic material and penetrated by numerous roots.

A2 (4 - 7 inches) whitish gray, heavy, very fine sandy loam with aggregations of granules on which specks of silica can be seen. Roots penetrate this horizon vertically.

B (7 - 17 inches) coffee brown silty clay, shading to a lighter color in the lower part of the horizon. The structure is mutty, breaking into fine granules. It is quite compact with a finer texture than A2. Root development is more extensive than in A2.

C (17 - 36 inches) light, buff colored clay - very fine sand. Numerous dots of Ca accumulation in the lower part of the horizon. It is the same material as in hori-C of profile 1. This profile represents a slightly podzolized soil. The horizons are in the process of formation and already have the features of podzol soils.

Profile 7.

Profile 7 represents the same soil as profile 6. It was taken about one half mile north of profile 6. The vegetation is practically the same. The samples were obtained July 10th.

Profile 8.

Profile 8 is a duplicate of profile 6 made by removing the loose earth from the original pit and cutting back one face about a foot before sampling. The samples were taken August 28th.

SOIL IV.

Profile 9.

Profile 9 was taken from a podzolic soil area developed from an alluvial deposit. It was sampled on July 19th and plated July 20th.

The sampled area is located about 50° 15' north latitude and 96° 03' west longitude, at the southern limits of the town of Lac du Bonnet and about 300 yards from the shore of Lac du Bonnet. The meteriological station situated at Pinawa, Manitoba, about 15 miles south east from the town of Lac du Bonnet reported monthly precipitation, maximum, minimum and mean temperatures as follows:-

Monthly mean temperatures and precipitation at Pinawa Man. for years 1924-32 and 1933.

Month	1924-32		1933	
	Deg F.	Prec. Ins.	Deg F.	Prec. Ins.
Jan.	-1.4	0.74	0.1	2.00
Feb.	6.0	0.64	-4.6	0.66
Mar.	16.4	0.80	13.7	0.36
April	40.5	1.02	34.2	0.57
May	48.3	1.01	53.1	1.10
June	58.0	1.38	54.4	0.98
July #	64.2	1.46	68.2	0.36
August	63.0	1.16	64.5	0.86
Sept.	52.5	1.40	55.4	1.28
Oct.	40.2	1.24	34.8	0.69
Nov.	21.0	1.19	14.7	2.18
Dec.	3.5	0.82	-9.2	1.24

samples obtained during this month.

The topography of the region is rolling but the area where the samples were obtained is a plain sloping towards the lake.

The area is heavily wooded and has considerable underbrush. The vegetation of this area consists of:- trees, Pinus resinosa, Populus tremuloides, Betula sp., Fraxinus nigor and Fraxinus pennsylvanica; shrubs, Amelanchier alnifolia, Rhamnus alnifolia, Cornus stolonifera, Acer spicatum, Viburnum opulus, Rubus americana, Lonicera oblongifolia, Rubus triflorus, Corylus americana, Corylus rostrata; herbs, Aralia nudicales, Carex strictum, Unifolium canadense, Smilacina stellata, Mitella nuda, Aster sp., Lappula echinata.

Description of Profile 9.

Ao (0 - 4 inches) undecomposed and partly decomposed forest debris forming a well-defined mat.

A1 (4 - 5 inches) horizon is very thin and poorly developed. Silty clay mixed with organic debris, structureless and dark colored.

A2 (5 - 8 inches) whitish gray fine sandy loam with indistinct line of demarcation from the overlying horizon A1 but quite distinct from the underlying horizon B. It has a platy structure which crushes into an ash-like powder; no visible organic matter.

B (8 - 19 inches) dark olive-brown silty clay with a granular structure. The granules are aggregated into larger clumps an inch or so in diameter; compact and heavier in texture than A2. Roots are developed very well in this horizon and a few earthworms exist.

C (19 - 37 inches and deeper) alluvial deposit of clay, very fine sand, light brown with accumulations of Ca. Structure is friable and coarser in texture than horizon B.

Profile 10.

Profile 10 is of the same soil as profile 9 and was obtained about one half mile from the lake and about 2 miles south of the town. It was sampled July 19th., and the wrapped samples were held in a cool basement until July 31 st. before plating. The picture of the profile is the same as that of profile 9 except that the B horizon is more compact and the aggregations of granules are somewhat larger in size.

SOIL V.

Profile 11.

Profile 11 was taken from a Highmoor soil. The location of the sampled area is 50° 25' north latitude and 96° 0' west longitude, about 3 miles west of Pinawa Falls and 5 miles east from the shore of Lac du Bonnet.

The peat soil is found in a valley about on half a mile wide where there is no outlet for drainage water.

The climate of this region is the same as reported for profile 9.

The vegetation of the valley area consists of the following dwarf trees: Larix laricina, Picea canadensis, Betula glandulosa, Populus tremuloides. The shrubs are: Chamaedafne calículata, Andromeda polifolia, Oxicoccus oxicoccus, Ledum groenlandicum. The herbs are: Geum strictum, Equisetum spp., Carex spp., and Aster spp. The plants mentioned above are growing amongst the sphagnum

moss together with some Polytrichum moss.

A pit for sampling was dug down to the heavy blue clay and samples were taken at three depths.

Description of Profile 11.

A (0 - 7 inches) the surface layer is a growing sphagnum layer which varies considerably in depth.

B (7 - 35 inches) the second layer, which is recorded as B, is a felted moss layer intermixed with branches of trees. Water logging begins at 20 inches and gradually increases with the depth. The sample was taken at a depth of from 27 to 35 inches.

C (58 - 64 inches) well decomposed remains of the sphagnum moss which are mixed with sticks and limbs of trees, the bark of which is decomposed. An odor of hydrogen sulphide is noticeable. Below 64 inches is a heavy blue clay layer.

Profile 12.

Profile 12 represents the same area as profile 11. The pit was dug about 100 yards south and across the road from profile 11. The morphological and organic characteristica are the same as in profile 11.

RESULTS OF STUDIES.

The results of the microbiological and chemical studies on the 5 soils studied are given in Tables I to IV. Charts 1 to 6 show the moisture distribution through the profiles. The data are shown graphically also. Figures 1, 4, 7 and 10 represent bacteria and actinomycetes, 2, 5, 8 and 11 actinomycetes alone, and 3, 6, 9 and 12 fungi. The relation of the microbiological population of the profiles to chemical and physical soil factors is shown in figures 13 to 15.

The numbers of bacteria and actinomycetes were highest in one of the three upper horizons in all cases. In profiles 1 and 2 the B horizons gave the highest counts. However, in wooded soils the A1 horizons were highest in count in the majority of cases and in Soil V the surface horizons were the highest. The counts of bacteria and actinomycetes in B2 of Soil I ranged from 12.1 to 28.9 per cent of the highest counts in the profiles. In the B horizons of Soils III. and IV, which were wooded, a similar calculation gave figures ranging from 11.7 to 31.5 per cent, except in the case of profile 8 where the B horizon gave the highest count in the profile.

The counts in the C horizons were uniformly low.

The counts of actinomycetes ranged from 0 to 43.7 per cent of the total number of micro-organisms counted on Brown's Sodium Albuminate Agar. They were highest in one of the two surface horizons in all profiles. There was a marked decrease in the B horizons in the prairie soils.

which was less noticeable in the wooded soils. The prairie soils showed no growth of actinomycetes from the C horizons of four profiles, while the C horizon of the wooded soils gave counts ranging from 4,000 to 120,000 per gram of soil.

Anaerobic bacteria showed varying counts throughout the profiles with the C horizons generally showing low counts.

The highest counts of fungi were found in the surface horizons in all cases. The decreases in the numbers of fungi in the second horizons were more striking than the decreases in any of the other micro-organisms studied. In the lower horizons the decreases were less marked. Even in the C horizons considerable numbers of fungi were found.

The algal flora is concentrated in the two surface horizons.

Protozoa were found only in the two surface horizons. In the majority of cases ciliata only were observed. Amoeba also were found in the surface horizons in profiles 4, 8, and 10.

DISCUSSION OF RESULTS.

In a review of the literature on the subject one finds that most workers report that organic matter, moisture, hydrogen ion concentration, season and soil type are the factors which control the density of micro-organisms in the soil.

In this report the above mentioned factors are present-

ed in table I and III. In order to trace the influence of these factors in Manitoba soils each will be discussed under a separate heading.

Organic matter.

There is no doubt that organic matter is the most important factor in the life of the majority of micro-organisms, because it is a source of food and energy.

Analyzing the results obtained it is evident that the highest percentage of organic matter is found in the surface horizons in all profiles studied: in all prairie soils in horizon A1, in wooded, Ao, and in organic, A.

Comparing the numbers of micro-organisms with the recorded per cent of organic matter in the corresponding morphologically well differentiated horizons the data indicate that organic matter is the factor which controls the activity of the soil micro-organisms during the vegetative period. The subsoil horizons contain only a small fraction of the organic matter of the surface horizons and also a correspondingly low fraction of the numbers of micro-organisms.

In the case of wooded soils horizon A2 in all cases showed a higher per cent of organic matter than horizon B. However, the total number of bacteria and actinomycetes in the majority of cases was higher in the B horizon. In the case of fungi a higher number was recorded from horizon A2 in the Fort Garry wooded soils and in the B horizon of the Lac du Bonnet wooded soil. In prairie soils a similar variation in the numbers of bacteria and actinomycetes occurred in the profiles which were sampled during May

but in the later samples it did not occur. Considering these data as facts the conclusion may be drawn that organic matter is not the only factor influencing the microbiological population of the subsoil horizons.

Moisture.

An analysis of the data makes it evident that the total moisture content of the soils studied does not show the true moisture picture of the soil. For example horizon A1 of profile 1 contained 1.52 times as much moisture as horizon C of the same profile. However the moisture equivalents of these horizons show that the A1 horizon can retain 45.42 per cent of moisture against a pull of 1000 times gravity exercised over a period of 40 minutes. At the same time horizon C retained only 19.7 per cent. Too, the moisture ratio ($\frac{T.M.}{M.E.Q.}$) of horizon C, as shown in chart 1, is 1.58 times as great as that of horizon A1. That means that horizon C, contains 2.48 times as much available moisture for plant growth as horizon A1. For this reason it would be a mistake to take into consideration the total soil moisture as a factor influencing the microbiological population in soil horizons. The moisture ratio ($\frac{T.M.}{M.E.Q.}$) of the morphologically corresponding horizons of profiles obtained from the same soil at different dates gives no definite relation to the biological population of these horizons. Even horizons in which the moisture ratio was below the wilting point showed higher numbers of micro-organisms than horizons which contained moisture available for plant growth.

Profile 8 of Soil III showed an abnormal distribution of microbiological population in comparison to the other wooded soil profiles studied. The samples of profile 8 were obtained August 28th., 3 days after a heavy rain occurred. The rain started August 22nd. and continued until August 25th. A total precipitation of 1.82 inches was recorded during the 4 days (20). Due to this fact horizon A1 gave the lowest counts of bacteria and actinomycetes and anaerobic bacteria and the second lowest of fungi in the profile. The hydrogen ion concentration also was the lowest of all horizons. Supposing that the acidity of this horizon is the limiting factor for bacteria and actinomycetes, then the fungi and algae should not be affected by this phenomenon. However the fungi were higher than in C horizon only. Accordingly acidity can not be considered as the limiting factor. Probably there is another soil factor acting as a soil disenfectant; to prove which one would need to make a complete chemical analysis and obtain much more data on the subject.

Acidity.

Thornton and Bear (23; page 398-400) obtained the highest counts of soil bacteria on agar at pH 7 and at slightly alkaline reactions. Russell (23; chapter VI.) stated that the "general result is that fungi preponderate in acid soils, while bacteria become numerically much more important in neutral soils, but this is not because fungi thrive better in an acid than a neutral medium but because

they tolerate acidity better than bacteria."

In our case all the profiles of the wooded soils studied showed the lowest hydrogen ion concentration in the A2 horizons. Due to this fact the numbers of bacteria and actinomycetes were lower also than in the B horizons. In prairie soils this phenomenon does not occur. In organic soils, Soil V in this case, the influence of the reaction of the soil is more pronounced than in any other soils studied. From the results we may conclude that acidity is a factor controlling the numbers of bacteria and actinomycetes.

Season.

A seasonal effect on the numbers of bacteria and fungi was reported by Brown and Benton (8) in Iowa soils. Conn (23; page 401) claimed that freezing of soil increases the number of bacteria. Lockhead (19) found higher numbers of bacteria in frozen soil than at ordinary summer temperatures and much larger numbers of bacteria when the soil begins to thaw.

Tables I and II show that in Soil I the numbers of bacteria were higher in the May samples than the June and September samples. It appears that numbers of bacteria decrease with increasing soil temperatures. A decrease in the numbers of bacteria in the late season occurred in all horizons (including C). The numbers of fungi were altogether different. They were low in May samples and gradually increased in numbers to the September samples. The numbers of fungi in horizon B and C remained practically

the same throughout the season. From the data obtained it is evident that with the increasing soil temperature or in the late season numbers of bacteria are decreasing through all the horizons in the profile, or a seasonal effect occurs in all the horizons of the soil profile. On the contrary, the numbers of fungi increased with increasing soil temperatures. A seasonal effect apparently does not occur in horizons B2 and C.

Soil type.

The numbers of micro-organisms obtained during June and July from the surface horizons of meadow prairie, wooded and organic soil types show that bacteria and actinomycetes in meadow prairie soils are 1.6 to 20.5 times as great as in wooded and 5 to 5.7 times as great as in organic soil types. Fungi however are greater in numbers in wooded and organic than in meadow prairie soils. The most noticeable characteristic in wooded soils is the striking increase of bacteria and actinomycetes from the Ao to the A1 horizons, which was recorded from all profiles except 8 and 10. This exception occurred in profile 8 due to excessive precipitation and in 10 probably because the samples were kept for 12 days in the basement before plating. Horizon A2 in wooded soils is a horizon of "depression" from which easily water soluble substances, organic as well as inorganic, are leached by percolating water and deposited in horizon B (23; chapter IV). Dur to this fact the B horizon showed, in nearly all cases, higher numbers of bacteria, actinomycetes and fungi than the A2 horizon, even though the B horizons are heavier in texture

and deeper than the A2 horizons. The numbers of micro-organisms in the well differentiated horizons of wooded soil profiles seem to be closely related to the morphological appearance of the horizons; in other words the microbiological and morphological horizons are identical in wooded soil.

The numbers of protozoa obtained from virgin soils in Manitoba were very low, compared to those reported by Russell and others (23; page 403 - 410). The hay infusion was made from hay containing alfalfa, timothy and agropyron. Possibly the alfalfa in the medium was toxic to many forms.

Strelkov (25) studying degraded chernozem soils by Koffman's method reported that no active forms were found in the surface soil. The quantitative protozoan population of the degraded chernozem soil was reported as follows:-

Amoeba	10 - 100
Flagellata	5,000 - 7,500
Infusoria	10 - 100

Taking into consideration the above figures it is possible that Manitoba virgin soils are poorly populated with protozoan fauna.

SUMMARY.

1. 12 profiles of 5 different virgin soils in Manitoba were sampled, described and analyzed for numbers of the various groups of soil organisms, moisture, hydrogen ion

concentration and organic matter content.

2. During June, July, August and September months the greatest numbers of the various organisms were found in the surface horizons in all 5 soils studied.

3. The proportion of anaerobic bacteria and anaerobic fungi to the total number of aerobic micro-organisms increases with the depth of the horizon in the profile.

4. Hydrogen ion concentration influences the numbers of bacteria and actinomycetes in a given horizon.

5. Variation in moisture content in the soils studied during the summer 1933 appears to have no influence on the numbers of micro-organisms.

6. Heavy precipitation destroys the normal distribution of micro-organisms in the soil profile.

7. In the meadow prairie phase soils the numbers of bacteria decrease in all horizons as the season advances. On the other hand fungi increase in numbers in the three upper horizons and remain unchanged in the B2 and C horizons.

8. The highest numbers of bacteria and actinomycetes in the surface horizons were found in the meadow prairie phase soils; and of fungi in the wooded and organic soils.

9. In the wooded soils the microbiological horizons appear to check with the morphological horizons.

10. The data suggest that organic matter content is an important factor in determining the numbers of micro-organisms that exist in the surface horizons.

TABLE I.

PHYSICO-CHEMICAL ANALYSES OF SOILS I AND II.

No.	Date 1933	Depth Ins.	Deg. C.	H_2O %	M.E.Q.	T.M. M.E.Q.	pH in H_2O	pH in KCl	Org. Mat. %
I-1	5/2	A_1(0-2)	9	37.9	45.42	0.83	7.31	6.68	8.04
		A_2(2-5)	7	27.7	37.27	0.74	8.35	7.26	3.18
		B_1(5-11)	5	30.5	34.53	0.88	8.27	7.45	2.41
		B_2(11-19)	3	29.3	32.82	0.89	8.24	7.54	1.76
		C(19-31)	0	24.9	19.70	1.26	8.16	7.69	0.86
I-2	5/15	A1(0-2)	17	25.6	52.39	0.49	7.71	6.81	19.44
		A2(2-5)	10	27.1	39.99	0.68	7.95	6.84	5.81
		B1(5-12)	6	31.6	38.60	0.82	8.11	7.24	2.36
		B2(12-20)	3	31.1	31.94	0.97	8.07	7.38	1.22
		C(20-27)	0	21.3	21.14	1.01	8.01	7.75	0.77
I-3	6/20	A1(0-2)	27	14.8	40.37	0.37	8.03	7.00	8.96
		A2(2-5)	24	24.2	41.00	0.59	8.08	6.98	6.54
		B1(5-9)	21	16.2	39.95	0.41	8.12	7.20	2.44
		B2(9-18)	20	22.3	37.90	0.59	8.29	7.44	1.56
		C(18-38)	17	20.0	23.22	0.86	8.12	7.52	0.87
I-4	9/21	A1(0-2)	12	82.0	53.67	1.52	7.46	6.75	22.26
		A2(2-6)	11	24.3	32.06	0.76	8.08	6.83	11.64
		B1(6-16)	12	31.7	41.72	0.76	8.09	6.80	2.45
		B2(16-27)	14	31.7	33.87	0.94	8.25	7.31	1.27
		C(27-44)	13	18.8	19.17	0.95	8.27	7.49	0.31
II-5	6/8	A1(0-3)	24	35.1	41.61	0.84	7.72	6.80	9.61
		AB(3-10)	19	28.9	35.23	0.82	7.95	6.86	3.95
		BC(10-40)	11	27.7	34.14	0.81	8.40	7.22	2.04
		C1(40-71)	7	38.1	57.02	0.67	8.03	7.19	2.30
		C2(71-76)	5	36.1	45.23	0.80	7.90	7.26	1.25

Notes:-

Under No. - the roman numeral represents the soil number, the arabic figures represent the profile number.

H_2O and T.M. - represent total moisture on the dry basis.

M.E.Q. - represents moisture equivalent.

TABLE II.

MICROBIOLOGICAL ANALYSES OF SOILS I AND II.

No.	Thous. Bacteria & Actino's.	Actino-mycetes	Anaerobic Bacteria	Fungi	Algae	Proto-zoa
1	54,500	4,850,000	1,000,000	26,000	1,000	-
	134,000	2,200,000	1,000,000	2,100	5,000	-
	159,000	700,000	10,000,000	320	0	-
	46,000	700,000	1,000,000	220	0	-
	6,000	0	1,000	90	0	-
2	40,000	2,430,000	-	28,000	10,000	-
	126,000	2,000,000	-	3,000	5,000	-
	147,000	600,000	-	380	500	-
	34,000	620,000	-	220	40	-
	6,000	0	-	40	0	-
3	23,000	3,800,000	1,000,000	46,000	10,000	40
	30,000	4,100,000	100,000	40,000	1,000	20
	5,100	400,000	100,000	1,000	0	0
	2,300	77,000	100,000	630	0	0
	217	230	1,000	98	0	0
4	22,200	3,200,000	1,000,000	60,000	1,000	100
	19,500	3,000,000	1,000,000	6,000	500	20
	17,300	650,000	10,000,000	2,500	0	0
	2,600	157,000	1,000	200	0	0
	280	0	1,000	40	0	0
5	22,200	2,900,000	100,000	44,125	5,000	40
	8,100	1,750,000	100,000	5,250	500	20
	1,200	50,000	10,000	160	0	0
	15	2,500	10,000	125	0	0
	10	0	1,000	17	0	0

Notes:-

Under No. - the arabic figures represent the profile number.

The sign - means no data available.

Only 2 or 3 significant figures are recorded in the counts of micro-organisms.

TABLE III.

PHYSICO-CHEMICAL ANALYSES OF SOILS III, IV AND V.

No.	Date 1933	Depth Ins.	Deg. C.	H_2O %	M.E.Q.	T.M. M.E.Q.	pH in H_2O	pH in KCl	Org. Mat. %
III-6	6/29	Ao(0-1)	18	99.0	108.69	0.91	7.39	6.86	60.78
		A1(1-4)	17	36.8	62.19	0.59	6.77	5.57	27.01
		A2(4-7)	15	14.4	25.97	0.55	6.36	5.36	3.52
		B(7-17)	14	23.9	44.27	0.54	7.14	5.97	2.12
		C(17-36)	12	18.5	22.44	0.82	8.16	7.54	0.35
III-7	7/10	Ao(0-3)	20	60.6	127.86	0.47	7.41	6.92	61.34
		A1(3-4)	18	17.8	27.55	0.65	7.21	6.61	19.18
		A2(4-10)	16	15.2	24.39	0.62	6.67	5.53	3.44
		B(10-18)	15	21.1	27.65	0.76	7.20	5.99	1.59
		C(18-38)	14	19.0	33.21	0.57	8.16	7.31	0.66
III-8	8/28	Ao(0-2)	14	83.3	75.05	1.11	7.31	6.82	40.37
		A1(2-3)	15	37.0	33.17	1.12	6.30	5.65	11.46
		A2(3-8)	15	16.9	25.55	0.66	6.50	5.82	3.13
		B(8-19)	15	20.7	36.81	0.56	7.30	5.96	3.38
		C(19-36)	14	12.1	13.64	0.89	7.95	7.16	0.32
IV-9	7/19	Ao(0-4)	17	56.9	132.17	0.43	6.39	6.01	91.92
		A1(4-5)	15	27.1	69.68	0.39	6.21	5.45	77.02
		A2(5-8)	14	14.1	29.65	0.48	5.94	5.17	17.90
		B(8-19)	11	21.4	40.28	0.53	7.38	6.24	17.26
		C(19-37)	11	19.4	30.68	0.63	7.94	7.18	0.63
IV-10	7/19	Ao(0-4)	17	48.7	122.96	0.40	6.55	5.83	64.17
		A1(4-5)	15	23.1	71.52	0.32	5.51	4.99	25.00
		A2(5-8)	14	13.6	29.39	0.46	5.50	4.64	4.47
		B(8-23)	11	19.1	33.68	0.57	6.37	5.95	2.60
		C(23-37)	11	18.7	35.74	0.52	7.81	7.06	0.95
V-11	7/20	Ao(0-7)	17	500.7	220.95	2.27	5.35	4.19	85.75
		B(27-35)	12	620.2	224.37	2.76	5.47	4.93	91.55
		C(58-64)	9	750.0	251.38	2.98	5.68	5.00	98.31
V-12	7/20	Ao(0-18)	17	500.7	190.22	2.63	4.78	3.86	90.24
		B(30-37)	12	620.2	188.92	3.28	5.43	4.92	68.00
		C(70-76)	9	750.0	232.91	3.22	4.39	4.68	88.91

Note:-

See notes under TABLE I.

TABLE IV.

MICROBIOLOGICAL ANALYSES OF SOILS III IV AND V.

No.	Thous. Bacteria & Actino's.	Actino-mycetes	Anaerobic Bacteria	Fungi	Algae	Proto-zoa
6	1,120	122,000	100,000	117,000	1,000	40
	37,000	7,500,000	1,000,000	15,600	1,000	10
	1,920	85,000	1,000,000	4,200	20	0
	5,200	950,000	1,000,000	990	0	0
	200	4,000	10,000	120	0	0
7	15,000	4,300,000	1,000,000	220,000	1,000	40
	38,000	9,000,000	1,000,000	26,000	1,000	20
	8,700	1,550,000	10,000	30,000	0	0
	12,400	1,800,000	1,000,000	2,400	0	0
	400	19,000	10,000	110	0	0
8	12,800	2,700,000	1,000,000	345,000	5,000	100
	850	0	100	3,500	0	10
	7,100	1,900,000	10,000	15,300	20	0
	16,000	2,500,000	100,000	16,400	0	0
	770	60,000	1,000	550	0	0
9	17,000	1,300,000	1,000,000	205,000	500	40
	89,000	16,000,000	10,000,000	65,000	5,000	20
	8,600	950,000	10,000	7,500	100	0
	11,000	1,250,000	100,000	14,700	100	0
	560	97,500	10,000	1,800	0	0
10	34,000	5,700,000	100,000	240,000	1,000	100
	8,000	3,500,000	1,000,000	20,000	100	20
	2,400	950,000	10,000	1,620	0	0
	4,200	900,000	100,000	10,600	0	0
	1,200	120,000	10,000	1,470	0	0
11	4,600	1,000,000	100,000	168,000	10,000	#
	1,250	200,000	100,000	1,620	500	0
	48	0	100,000	500	20	0
12	4,000	1,150,000	100,000	370,000	10,000	#
	2,700	10,000	100,000	3,100	500	0
	63	0	100,000	870	0	0

Notes:-

See notes under TABLE II.

- present in small chunk of soil.

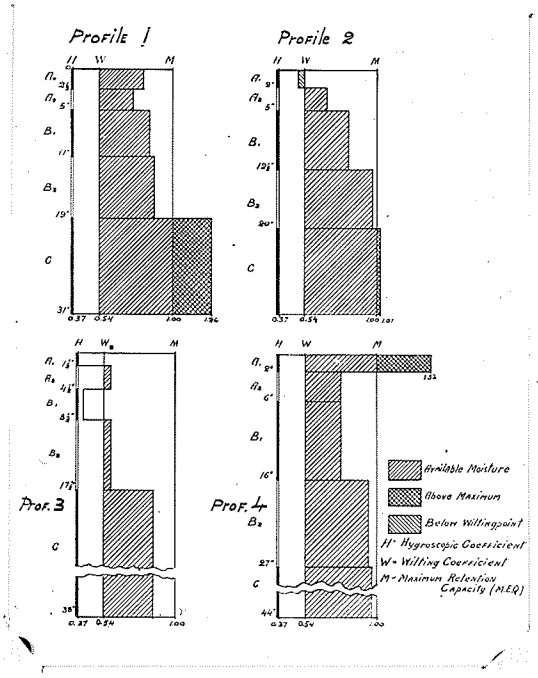


Chart 1. Moisture distribution through the profiles of soil I.

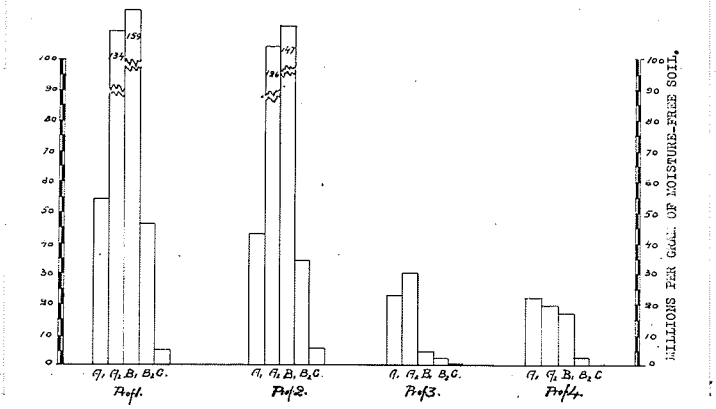


Fig. 1. Bacteria and actinomycetes in the profiles of soil I.

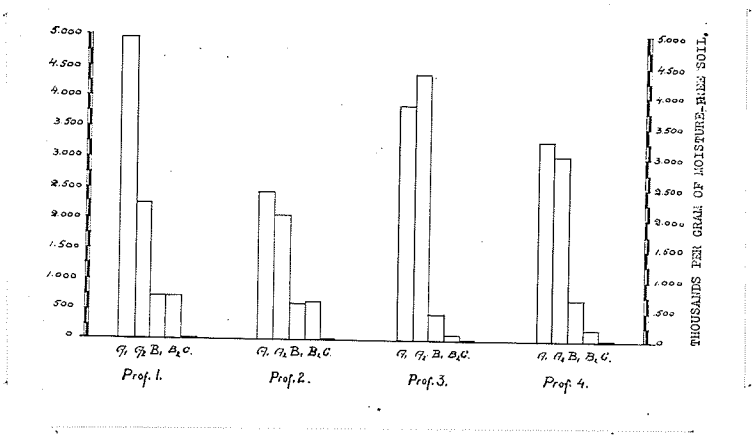


Fig. 2. Actinomycetes in the profiles of soil I.

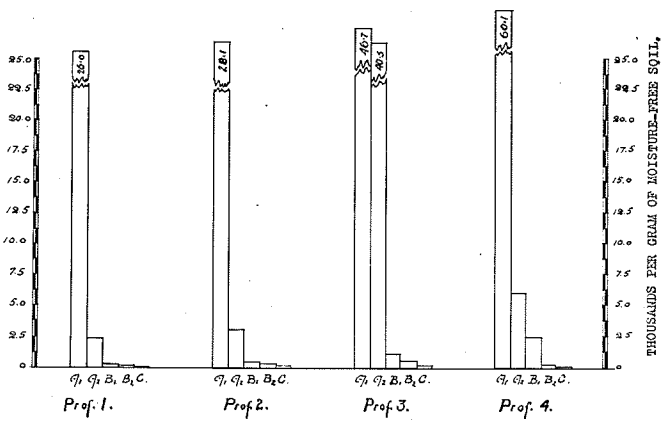
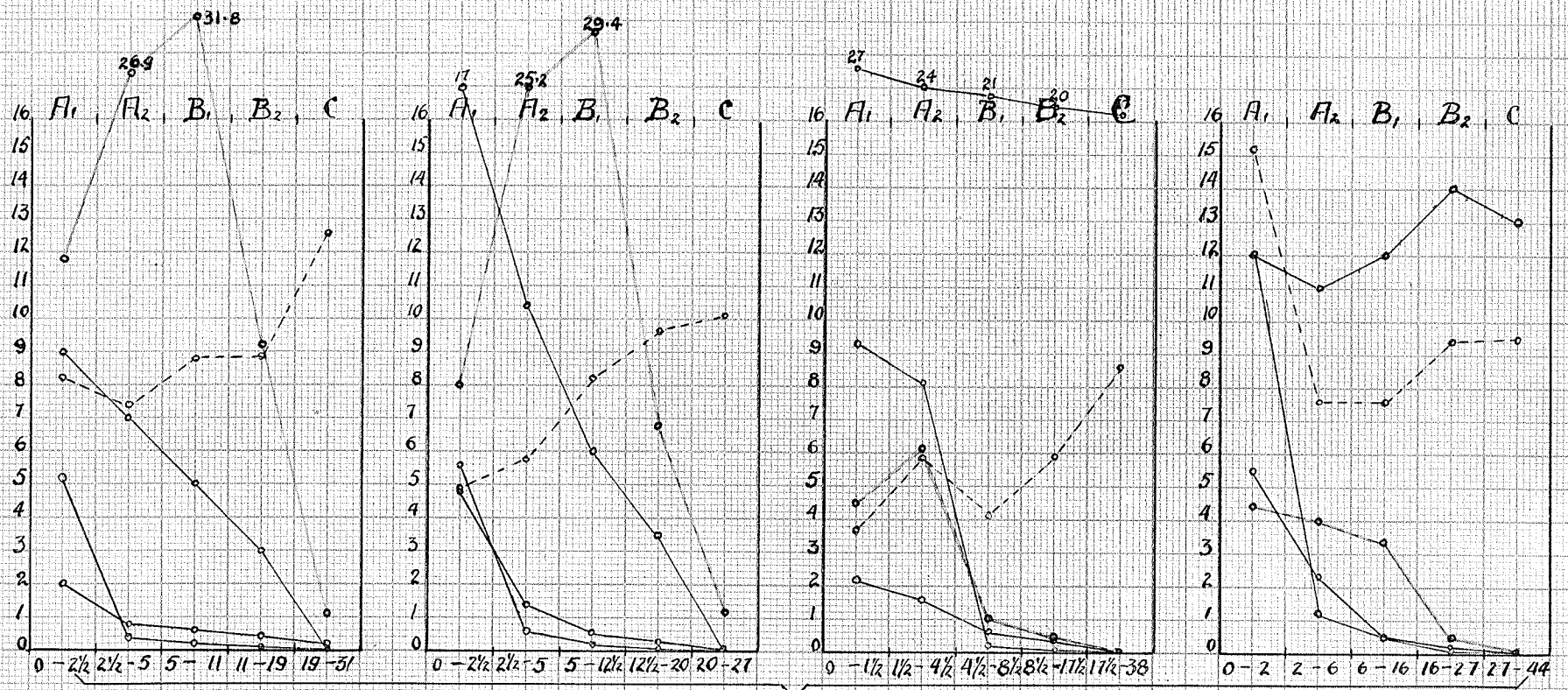


Fig. 3. Fungi in the profiles of soil I.

Figure 13. Soil 1.



Profile 1. Profile 2. Profile 3. Profile 4.

---- Moisture Ratio $\left(\frac{1 \text{ M.}}{\text{M.E.Q.}}\right)$; 0·1 per cent = One unit

—— Organic Matter ; 4 per cent = " "

—— Bacteria and Actn.; 5 mill. = " "

—— Fungi ; 5 thous. = " "

—— Temperature ; 1°C = " "

Relation of Microbiological Population to Physical and Chemical Soil Factors.

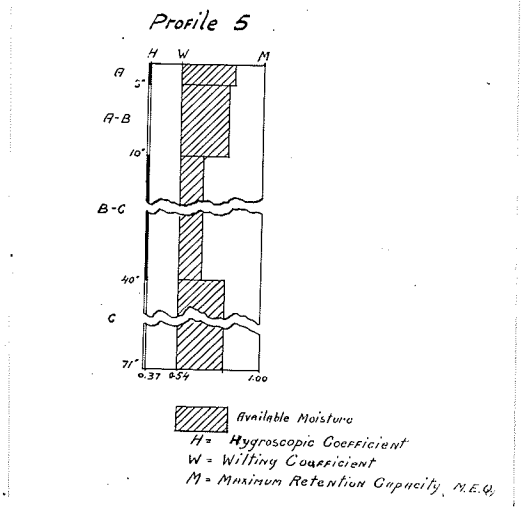


Chart 2. Moisture distribution through the profiles of soil II.

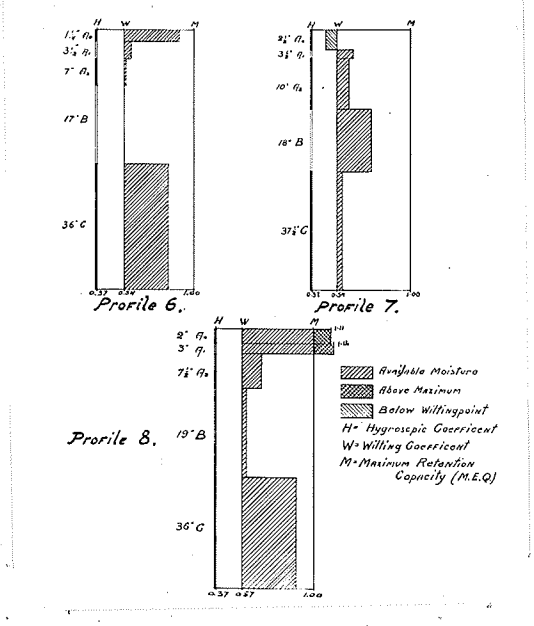


Chart 3. Moisture distribution through the profiles of soil III.

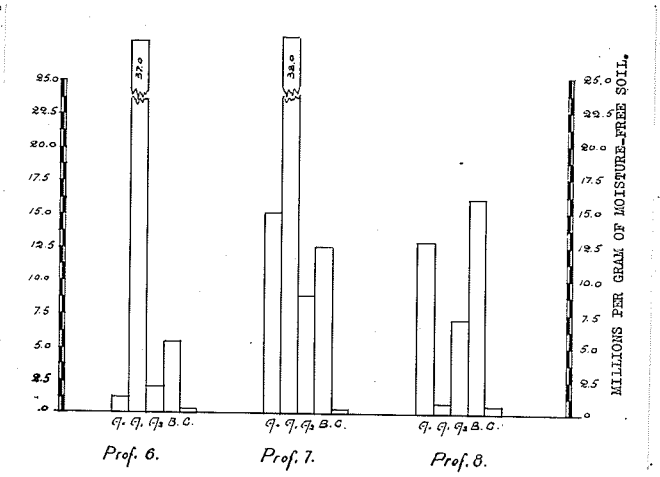


Fig. 4. Bacteria and actinomycetes in the profiles of soil III.

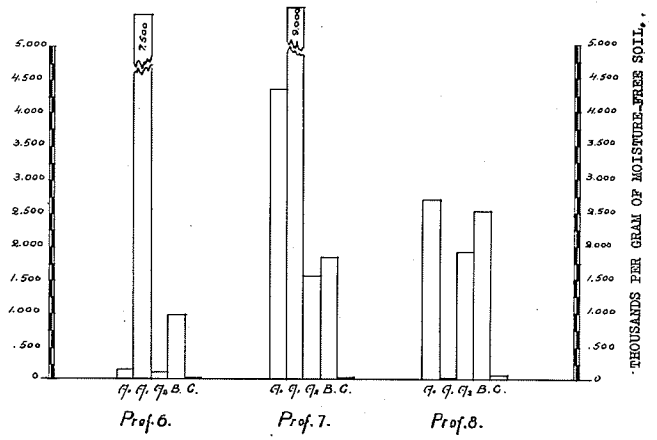


Fig. 5. Actinomycetes in the profiles of soil III.

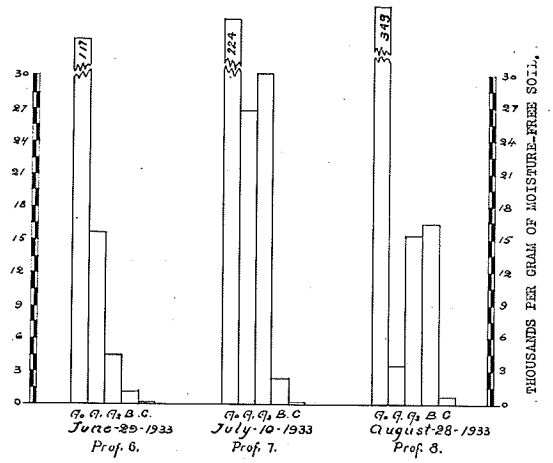
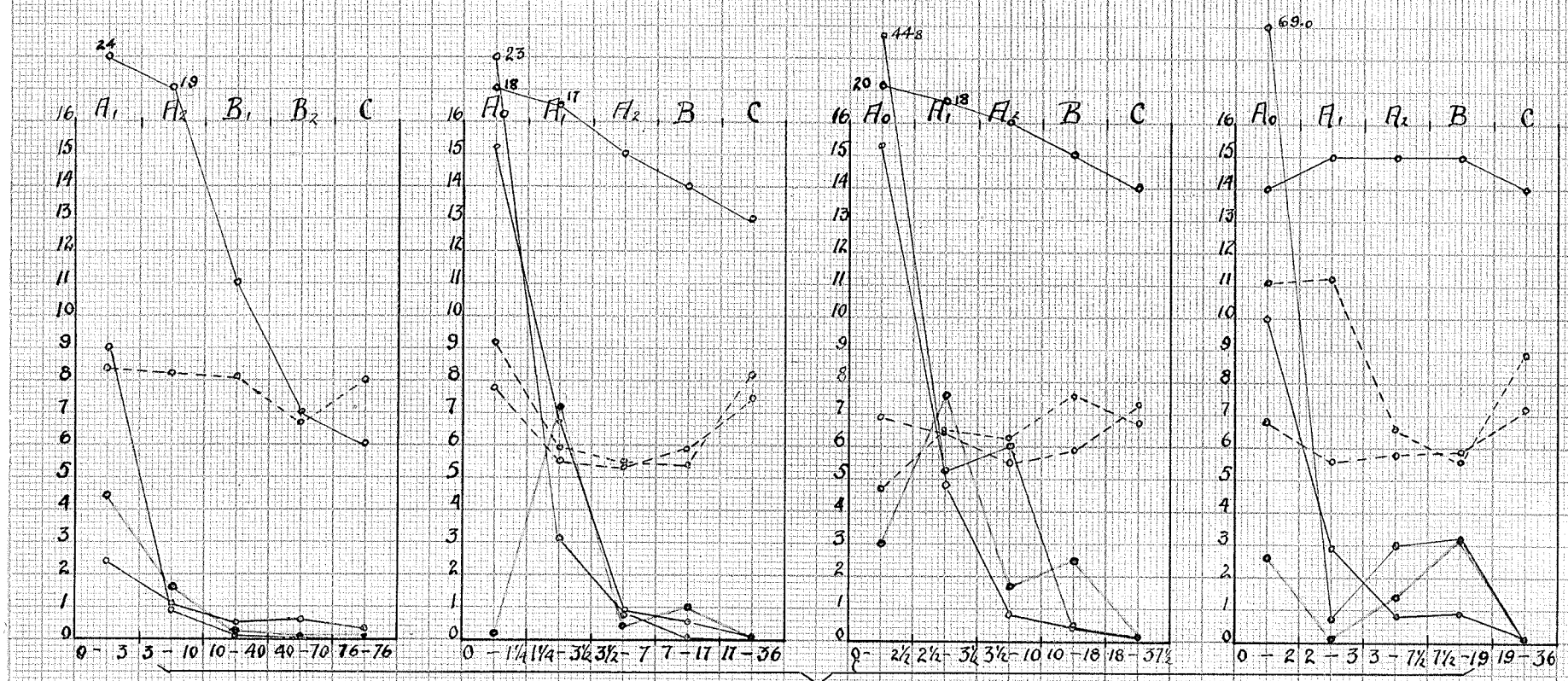


Fig. 6. Fungi in the profiles of soil III.

Figure 14. Soil 2 and 3.



Profile 5 Profile 6 Profile 7 Profile 8

----- Moisture Ratio: $\left(\frac{\text{T.M.}}{\text{M.E.Q.}}\right)$; 0.1 = One unite

——— Organic Matter; 4 per cent = " "

——— Bacteria and Actinom.; 5 mill = " "

——— Fungi ; 5 thous. = " "

——— Temperature; 1° C = One unit

----- p H ; 1° = " "

Relation of Microbiological Population to Physical and Chemical Soil Factors.

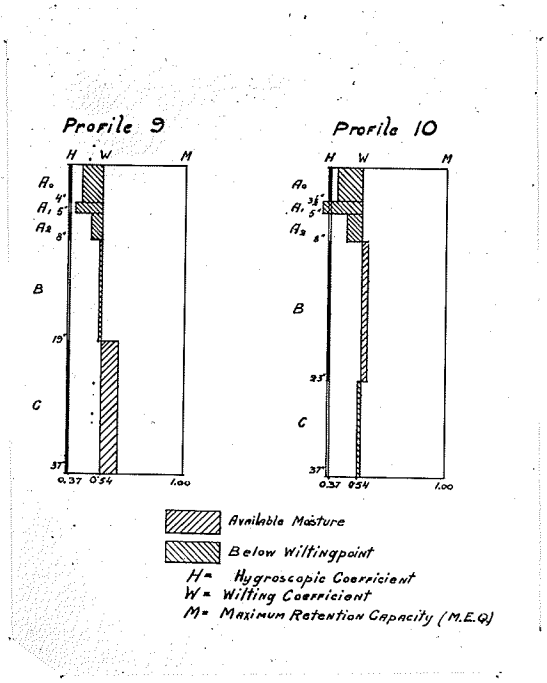


Chart 4 - Moisture distribution through the profiles of soil IV

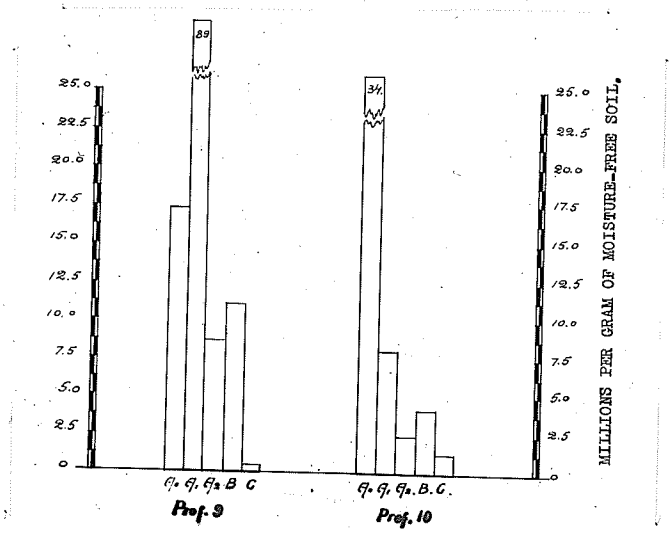


Fig. 7 - Bacteria and actinomycetes in the profiles of soil IV.

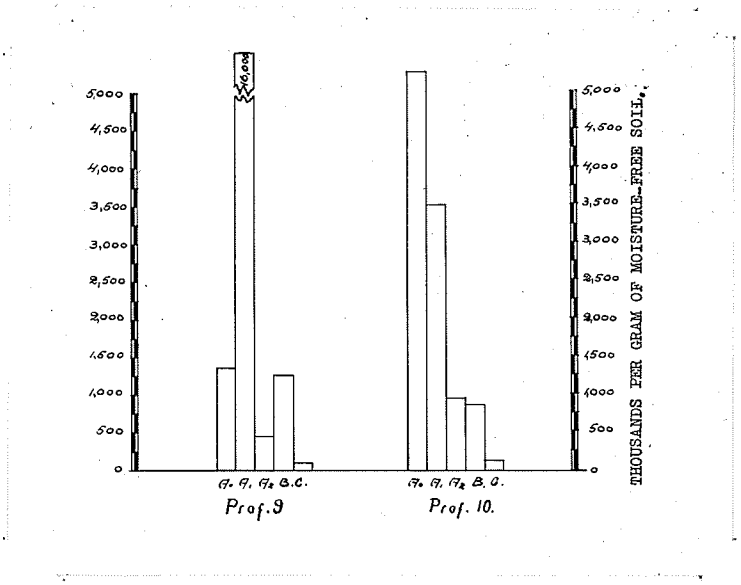


Fig. 8 - Actinomycetes in the profiles of soil IV

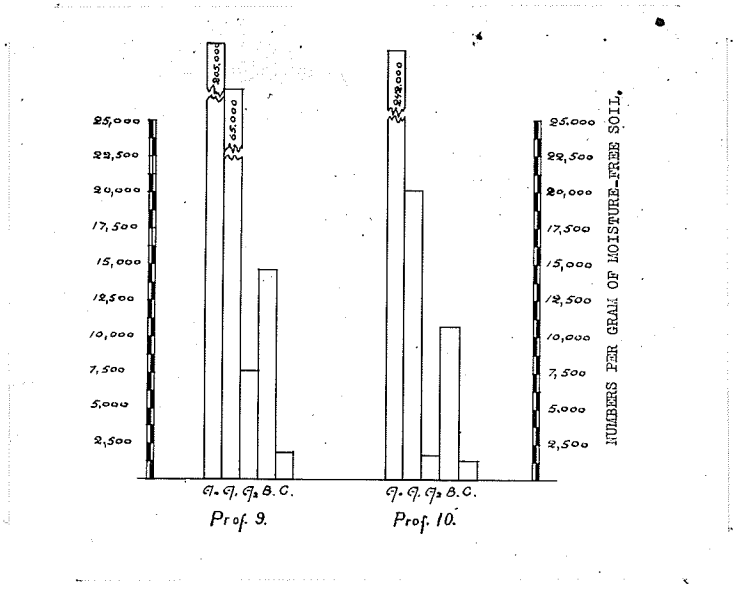
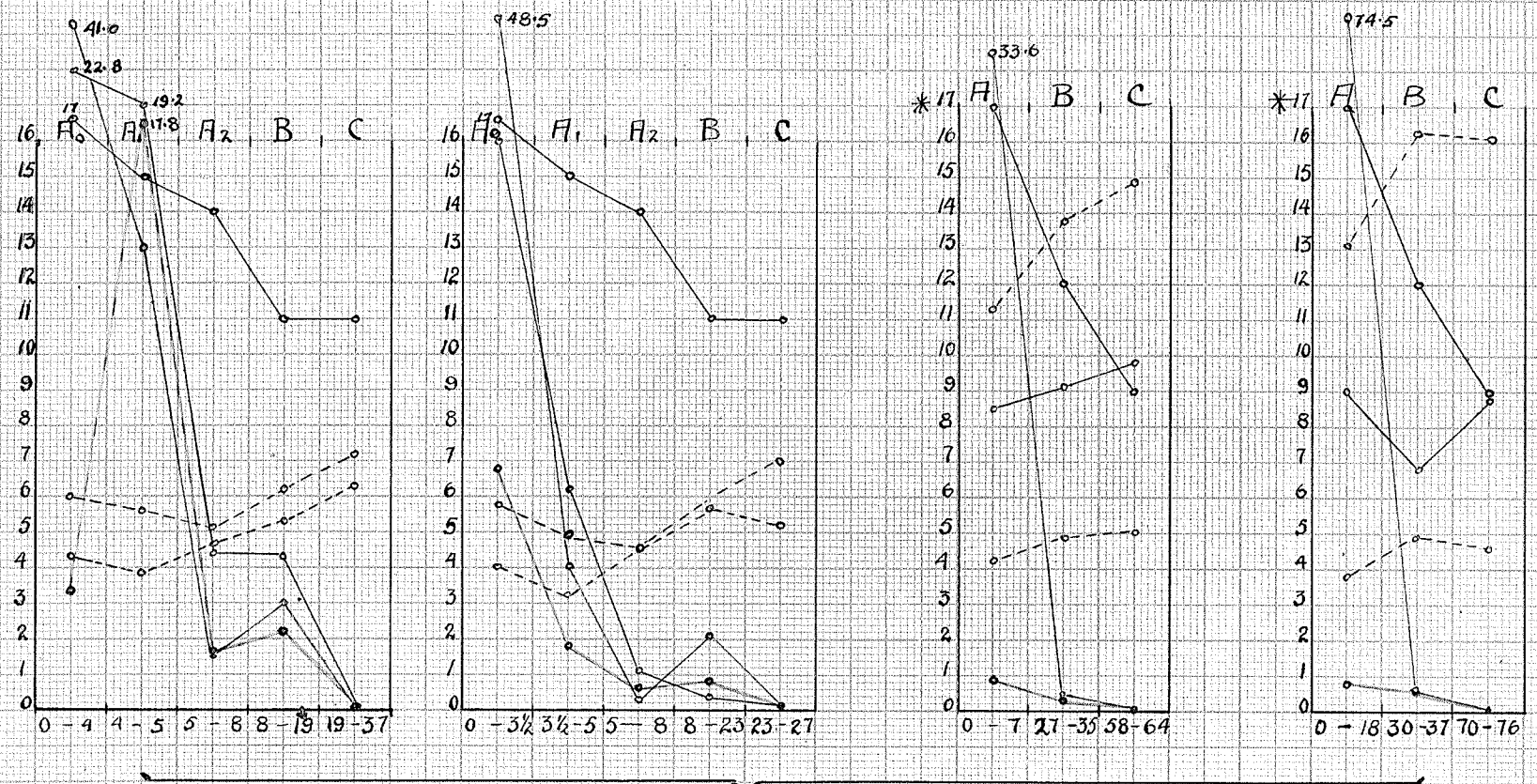


Fig. 9 - Fungi in the profiles of soil IV.

Figure 15. Soil 4 and 5.



Profile 9.		Profile 10.		Profile 11.		Profile 12.	
- - - -	Moisture Ratio $\left(\frac{\text{TM.}}{\text{MEQ}}\right)$	; 0·1 per cent	= One unit	——	Temperature ; 1°C.		= One unit
——	Organic Matter	; 4 per cent	= " "	- - - - -	pH ; 1°		= " "
——	Bacteria and Actin.	; 5 mill.	= " "	——	* Organic Matter	; 10 per cent	= " "
——	Fungi	; 5 thous.	= " "	- - - - -	* Moisture Ratio	; 0·2 per cent	= " "

Relation of Microbiological Population to Physical and Chemical Soil Factors.

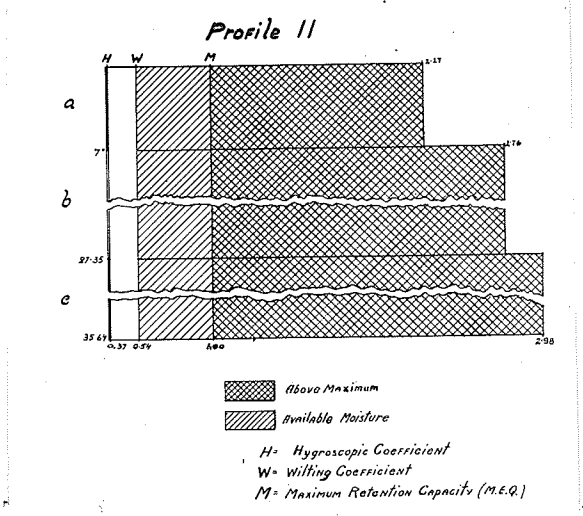


Chart 5 - Moisture distribution through profile 11

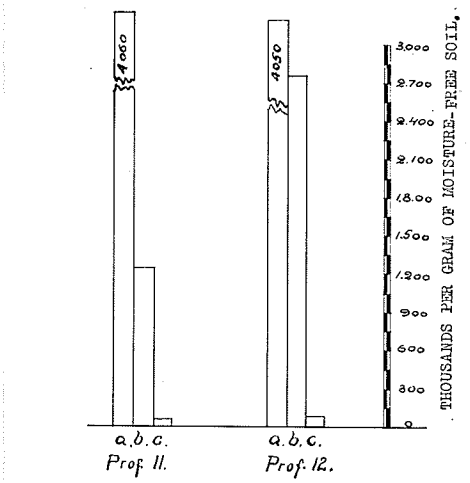


Fig. 10 - Bacteria and actinomycetes in the profiles of soil V.

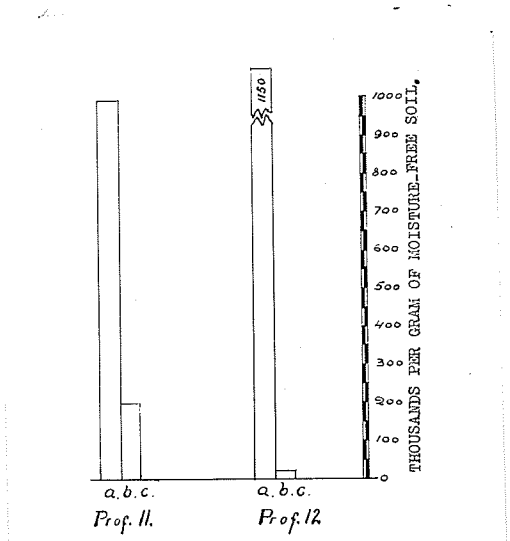


Fig. 11 - Actinomycetes in the profiles of soil V

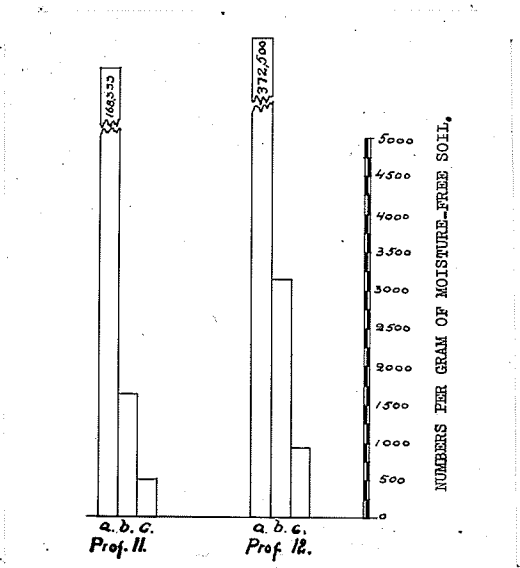


Fig. 12 - Fungi in the profiles of soil V.

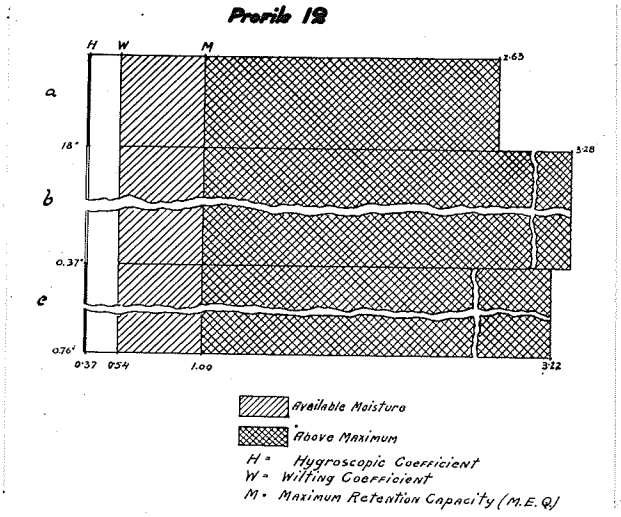


Chart 6 - Moisture distribution through profile 12.

PART II.

GENERA OF FUNGI.

INTRODUCTION AND HISTORICAL.

Only within the last half century has the attention of microbiologists and plant pathologists been directed to the soil as the natural habitat of many micro-organisms and as a sphere for the development of and source of infection of many kinds of fungal and bacterial plant disease. Due to the importance of these organisms to agriculture the number of systematic studies on soil micro-organisms is increasing yearly. Leopold Adametz in 1886 is credited with being the first to report on fungi isolated from the soil. The number of species has been increased from the 11 described by him to more than 250 at the present time.

The fungus-flora of surface soils has been considered by many investigators. Bisby, James and Timonin (4) published results of their systematic studies of the fungus-flora of some Manitoba soils. Miss Dale in 1912 and 1914 reported lists of soil fungi isolated from English soils (9) (10). Jensen (16), Gilman and Abbott (14), Miss Todd (28) Le Clerg (17) and Waksman (30) have made great contributions

to the knowledge of the fungus-flora of American soils. Ziling (32) reported on the fungus-flora of 72 samples of Siberian cultivated soils at 3 depths, 3-5, 8-10 and 18-20 centimeters. He identified 37 genera, including 15 forms of Fusarium. Penicillium accounted for more than 50 per cent of the fungi in 43 of the samples and Cladosporium more than 20 per cent in 5 samples. Yeasts ranked third in the soils he studied.

PROBLEM.

This section of the study is a report on the types of fungi isolated from the plates in the samples referred to in Part I. The fungus-flora included in the work refers to the true fungi belonging to the classes Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti.

METHODS.

After the fungi were counted one plate showing good distribution of colonies was selected and each colony transferred to a Czapek's (non acidified) agar slant for incubation and study. The other plates were examined and any type appearing different from those already picked was transferred also. Fungi belonging to the Mucorales were grown on potato sucrose agar (non acidified) which was substituted for potato dextrose agar used in an earlier work (4). The potato sucrose agar medium was prepared as follows:-

250 grams of washed and peeled potatoes were cooked in 1 litre of tap water for 1 hour over a boiling water bath.

The potatoes were strained and the extract made up to 1 litre with tap water. The agar and sugar were added and the medium melted and tubed and sterilized at 15 lbs. steam pressure for 15 minutes.

The composition of the medium follows:-

Potato	250	grams.
Sucrose	30	"
Agar	20	"
Tap water	1000	ml.

Isolations were made also from plates incubated in a CO_2 chamber and from plates incubated at 37° C. (see part I.) These transfers were incubated under the same conditions as the plates from which they were isolated.

RESULTS OF STUDIES.

A summary of the genera of fungi isolated from the different horizons of the 12 profiles is presented in tables V, VI and VII.

Table VIII presents a summary of the data in tables V, VI and VII and shows the actual number of isolations of species representing each genus.

TABLE V.

OCCURRENCE AND DISTRIBUTION OF FUNGI IN SOIL I#

Genus	Profile 1					2					3					4				
	A 1	A 2	B 1	B 2	C	A 1	A 2	B 1	B 2	C	A 1	A 2	B 1	B 2	C	A 1	A 2	B 1	B 2	C
Absidia	x					x			x		x		x	x	x	x	x	x		
Gymnoascus																	x			
Saccharomyces											x		x			x				
Acrostalagmus	x														x					
Aspergillus	x	x			x						x	x	x	x	x					
Botrytis	x			x														x		
Cephalosporium							x		x		x							x		
Cylindrocarpon	x		x	x		x	x				x		x	x		x	x	x	x	
Fusarium	x										x	x								
Geotrichum															x					
Gliocladium																		x		
Hymenula								x					x				x			
Isaria															x					
Penicillium	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		
Spicaria										x										
Sporotrichum	x														x					
Trichoderma																	x	x		
Verticillium															x					
Alternaria																x	x			
Monosporium		x	x																	
Cladosporium											x					x				
Helmintho-sporium	x					x														
Monotospora								x			x	x	x	x						
Stachybotrys													x							
Periconia												x								
Stemphylium	x	x				x	x													
Tilachlidium	x	x	x														x	x		
Phoma											x	x	x	x						

For description of Soil I see page 6.

TABLE VI.

OCCURRENCE AND DISTRIBUTION OF FUNGI IN SOILS II AND III.#

Genus	Soil II. Prof. 5					Soil II. Prof. 6					Soil III. Prof. 7					Soil III. Prof. 8				
	A	A B	B C	1	C 2	A o	A 1	A 2	B	C	A o	A 1	A 2	B	C	A o	A 1	A 2	B	C
Absidia	x					x					x					x		x		
Cunninghamella						x														
Mortierella						x	x				x	x				x			x	
Mucor						x					x					x	x			
Rhizopus												x								
Zygorhynchus														x						
Monascus							x	x			x	x				x		x	x	x
Saccharomyces			x						x									x		
Rhizoctonia														x						
Acrostalagmus													x			x				
Aspergillus	x					x				x	x	x				x				
Botrytis																x				
Cephalosporium	x						x	x	x	x		x	x	x			x	x	x	
Cylindrocarpon	x	x		x			x		x				x	x	x			x	x	x
Fusarium		x				x														
Geotrichum							x													x
Gliocladium						x		x												
Penicillium	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trichoderma	x					x	x	x	x	x	x	x	x	x		x		x	x	x
Verticillium		x									x					x				
Alternaria		x								x	x					x				
Cladosporium							x						x					x		x
Hormodendrum												x	x						x	
Stachybotrys							x													
Stemphylium							x			x										
Colletotrichum						x														
Coniothecium			x		x				x											
Coniotherium										x	x					x				
Cytospora									x											
Phoma	x	x	x			x												x		

For description of Soils II and III see pages 10 - 12.

TABLE VII.

OCCURRENCE AND DISTRIBUTION OF FUNGI IN SOILS IV AND V.#

Genus	Soil IV. Prof. 9					Prof. 10					Soil V. Prof. 11			Prof. 12		
	A o	A 1	A 2	B	C	A o	A 1	A 2	B	C	A	B	C	A	B	C
Absidia	x			x		x										
Mortierella	x										x		x	x	x	x
Mucor		x									x	x				
Rhizopus	x															
Chaetomium									x							
Gymnoascus															x	
Monascus	x	x	x	x		x	x				x	x	x	x	x	x
Pleospora			x													
Aspergillus			x				x							x		
Cephalosporium	x	x		x		x						x				
Fusarium				x						x						x
Geotrichum	x															
Metarrhizium				x												
Mycoderma															x	x
Penicillium	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Trichoderma	x		x	x		x	x	x	x		x	x		x	x	x
Verticillium				x			x	x								
Alternaria			x				x								x	
Haplographium		x														
Helmentho-sporium						x										
Macrosporium													x			
Stachybotrys	x															
Coniotherium	x															
Phoma						x										

For descriptions of Soils IV and V see pages 13 - 16.

TABLE VIII.

SUMMARY OF FUNGI IN THE SOILS STUDIED.

Class and Genus	Number of # entries	Number of " isolations
Phycomycetes		
Absidia	18	47
Cunninghamella	1	4
Mortierella	12	39
Mucor	4	18
Rhizopus	2	2
Zygorhynchus	1	1
Ascomycetes		
Chaetomium	1	1
Gymnoascus	2	3
Humarina	2	6
Monascus	20	47
Pleospora	1	2
Xylaria	1	4
Basidiomycetes		
Rhizoctonia	1	1
Fungi Imperfecti		
Moniliaceae		
Acrostalagmus	4	8
Aspergillus	17	26
Botrytis	4	7
Cephalosporium	20	44
Cylindrocarpon	23	62
Fusarium	8	30
Geotrichum	4	4
Gliocladium	3	7
Hymenula	3	3
Isaria	1	2
Metarrhizium	1	1
Monosporium	2	4
Mycoderma	2	2
Penicillium	53	918
Spicaria	1	1

TABLE VIII. (Continued)

Class and Genus	Number of entries	Number of isolations
Fungi Imperfecti		
Moniliaceae (Continued)		
Sporotrichum	2	4
Trichoderma	20	100
Verticillium	9	21
Dematiaceae		
Alternaria	9	10
Cladosporium	6	11
Haplographium	2	3
Helminthosporium	3	3
Hormodendrum	3	4
Macrosporium	1	1
Monotospora	5	10
Periconia	1	1
Stachybotrys	1	2
Stemphylium	6	8
Tilachlidium	5	27
Melanconiales		
Colletotrichum	1	1
Sphaeropsidales		
Conotheeium	3	8
Coniotherium	4	13
Cytospora	1	3
Phoma	10	26
Totals 47 genera	304 entries	1550 cultures

\# Number of samples from which isolated.

" Number of isolations belonging to the genus.

DISCUSSION OF RESULTS.

In an examination of 2257 isolations from 56 samples obtained from 12 profiles, 1550 cultures have been indentified. These represent 47 genera. Representatives of 14 genera not previously recorded as found in Manitoba soils appear in table VIII. They include:-

Cunninghamella - 4 isolations from a wooded soil.

Humarina - 6 isolations from a wooded soil on plates incubated at 37° C.

Monascus - 47 isolations from 20 samples scattered throughout the profiles in wooded and organic soils.

Xylaria - 3 isolations from a meadow prairie soil on plates incubated at 37° C.

Isaria - 2 isolations from a meadow prairie soil.

Monosporium - 4 isolations from 2 samples of a meadow prairie soil.

Mycoderma - 2 isolations from 2 samples of an organic soil.

Haplographium - 3 isolations from wooded and meadow prairie soils on plates incubated at 37° C.

Hormodendrum - 4 isolations from a wooded soil.

Macrosporium - 1 isolation from an organic soil.

Periconia - 1 isolation from a meadow prairie soil.

Stachybotrys - 2 isolations from a meadow prairie soil.

Tilachlidium - 13 isolations from meadow prairie soils.

Coniothecium - 4 isolations from wooded and meadow

prairie soils.

The advisability of varying the incubation temperature is shown by the fact that species belonging to 3 extra genera were isolated at 37° C. The plates incubated at this temperature represented low dilutions of the samples and, consequently, there was a greater chance of isolating types that are few in number in a given sample. At the same time the temperature of incubation was a factor in inhibiting most types of fungi, so that forms capable of growing at this temperature were permitted to develop freely. The numbers growing at this temperature represented from 0 to 1.6 per cent of the counts on plates incubated at 25° C., showing clearly the inhibiting effect of the higher temperature. All of the isolations made at 37° incubation were from the first two horizon samples.

Plates incubated in a CO_2 chamber yielded the same genera as those under aerobic conditions. The counts were from 0.6 to 78.6 per cent of the counts on plates incubated aerobically. It would appear therefore, that many fungi are facultative in their oxygen requirement.

Representatives of the various genera appear to be distributed throughout the various horizons of the profile. For example Penicillium occurred in all except 3 of the 56 samples analyzed. These 3 were the B2 and C horizons. Cephalosporium also was well distributed, having been found in 21 samples representing all horizons and all soils.

Some genera appear commonly in one type of soil and are not found in other types. For example Monascus was

found only in the wooded and organic soils. Cylindrocarpon occurred in 23 samples taken from the meadow prairie and wooded soils of the Fort Garry association and was not found in 16 samples of wooded and organic soils.

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