A study of the fertility status of Blodgett sandy loam

by Alexander Pope

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Soils
Montana State University

Abstract:
A study of the fertility status of Blodgett sandy loam was made in an attempt to obtain the necessary preliminary information on which to base comprehensive fertilizer tests for some of the soils of low productivity in the Bitterroot Valley.

Three greenhouse fertility tests were conducted in the winter and spring of 1950 using corn, sunflowers and sweetclover as test crops. In the spring of 1950, three field fertility tests were placed in the area concerned. The first test was placed on Alsike clover with oats as a nurse crop, the second on Hubam sweetclover, and the third test was placed on mixed hay with oats as a nurse crop. These tests were supported by a chemical analysis of the soil. The results of the chemical analysis indicated that the soils were low in total and CO_2 extractable phosphorus, low in nitrates, and low in exchangeable calcium and magnesium. The soils varied in exchangeable potassium, with some being very low and others quite high. The cropped soils were low in organic matter and the cation exchange capacity was relatively low. The soils were medium to strongly acid and had a low buffering capacity.

The results of the fertility tests indicated that under greenhouse conditions, corn, sunflowers, and sweetclover responded to a combination of nitrogen and phosphate fertilizer. The corn and sunflowers also responded to an application of barnyard manure and to potassium when grown in the soil with the low exchangeable potassium level. When the fertility level was brought up high enough, corn responded to an application of boric acid.

Under field conditions, oats, clover, and mixed hay responded to a combination of nitrogen and phosphate fertilizer. On the basis of the chemical analysis it appears that the response to the nitrogen-phosphorus combination is not due to either element alone, but is equal to or greater than the summation of the response to both elements.

The Blodgett soils are low in many of the essential nutrient elements and as the fertility level is raised by the application of fertilizers, some of the minor elements may become limiting. Further fertilizer tests should be conducted on different crops grown in the area in order to determine the rates and combinations of fertilizers needed at various nutrient levels.

A STUDY OF THE FERTILITY STATUS OF BLODGETT SANDY LOAM

by

ALEXANDER POPE

A THESIS

Submitted to the Graduate Faculty

in

partial fulfillment of the requirements

for the degree of

Master of Science in Soils

at

Montana State College

Approved:

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

Bozeman, Montana
August, 1950

ACKNOWLEDGMENT

The writer wishes to acknowledge the assistance given him by the Agronomy and Soils Department staff, especially Dr. J. C. Hide who suggested the problem and gave valuable advice and assistance during the course of this study. Acknowledgment is also due Dr. E. R. Hehn for his assistance in setting up the experimental designs and in the analysis of the data, and to Mr. W. C. Bourne who assisted in obtaining the soil samples and furnished valuable information for the soil description.

The writer also wishes to express his appreciation to Mr. G. P. Hartman for his assistance in placing the field fertilizer tests and to the cooperating farmers, especially Mr. Henry Oppeguard who furnished the soil for the greenhouse tests.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (continued)

ABSTRACT

A study of the fertility status of Blodgett sandy loam was made in an attempt to obtain the necessary preliminary information on which to base comprehensive fertilizer tests for some of the soils of low productivity in the Bitterroot Valley.

Three greenhouse fertility tests were conducted in the winter and spring of 1950 using corn, sunflowers and sweetclover as test crops. In the spring of 1950, three field fertility tests were placed in the area concerned. The first test was placed on Alsike clover with oats as a nurse crop, the second on Hubam sweetclover, and the third test was placed on mixed hay with oats as a nurse crop. These tests were supported by a chemical analysis of the soil.

The results of the chemical analysis indicated that the soils were low in total and CO_2 extractable phosphorus, low in nitrates, and low in exchangeable calcium and magnesium. The soils varied in exchangeable potassium, with some being very low and others quite high. The cropped soils were low in organic matter and the cation exchange capacity was relatively low. The soils were medium to strongly acid and had a low buffering capacity.

The results of the fertility tests indicated that under greenhouse conditions, corn, sunflowers, and sweetclover responded to a combination of nitrogen and phosphate fertilizer. The corn and sunflowers also responded to an application of barnyard manure and to potassium when grown in the soil with the low exchangeable potassium level. When the fertility level was brought up high enough, corn responded to an application of boric acid.

Under field conditions, oats, clover, and mixed hay responded to a combination of nitrogen and phosphate fertilizer. On the basis of the chemical analysis it appears that the response to the nitrogen-phosphorus combination is not due to either element alone, but is equal to or greater than the summation of the response to both elements.

The Blodgett soils are low in many of the essential nutrient elements and as the fertility level is raised by the application of fertilizers, some of the minor elements may become limiting. Further fertilizer tests should be conducted on different crops grown in the area in order to determine the rates and combinations of fertilizers needed at various nutrient levels.

A STUDY OF THE FERTILITY STATUS OF BLODGETT SANDY LOAM

by

ALEXANDER POPE

INTRODUCTION

For many years a fertility problem has been known to exist in many of the soils on the west side of the Bitterroot Valley. While some work with commercial fertilizers has been done in the area, it has not indicated a method by which these soils could be brought up to a satisfactory level of productivity. The present study was undertaken to further study the problems associated with crop production on these soils.

It was decided to limit the study to one soil series which had been found to occur fairly extensively over the area. Since there are about 40,000 acres of the Blodgett series and an additional 60,000 acres of genetically related soils such as Como, Bass, Charlos, and Victor in this area, a study of the fertility status of Blodgett sandy loam seemed advisable.

The Blodgett series of soil was first mapped in the Bitterroot Valley in Ravalli County, Montana. The type location is about six miles north of Hamilton. It is distributed quite extensively in the Bitterroot Valley, especially on the west side of the river, and probably in other areas in Western Montana and in adjacent states. These soils are used for growing dry-land and irrigated pasture and irrigated hay. In the Bitterroot Valley a small acreage is devoted to small grains under irrigation and to apple and cherry orchards.

Following is a description of the Blodgett series and a profile description of Blodgett sandy loam as set up by the Division of Soil Survey, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

Blodgett Series

"The Blodgett series includes noncalcareous grassland soils developed from granitic and gneiss materials on old alluvial outwash fans in intermountain valleys and on mountain footslopes in the Northern Rocky Mountains. They are in a climatic belt approximating that of the Chestnut soil zone, but they are in a zone of transition from Chestnut to podzolic soils, and the Chernozem soils are absent as a rule. Subangular and rounded gravel, cobble and boulders comprise a high percentage of the alluvium. The stone fragments are moderately to strongly weathered in place and have contributed material to the soils. The Blodgett series differ from the Bass and Charlos soils in having lighter colored, more grayish, less reddish and brown, thinner and lighter-textured subsoils. They have darker surface layers than Como soils which have been developed under forest cover on alluvial fans of similar materials.

Soil profile: (Blodgett sandy loam)		Range in Thickness
0-10"	Brownish-gray (10YR 5/1 dry) to very dark grayish-brown (10YR 3/1 moist) gritty sandy loam; faintly platy in upper part, slightly blocky cleavage in lower part; crushes easily to crumb-like mass; slightly acid or neutral.	7-12"
10-16"	Brown (10YR 5/2 dry) to dark brown (10YR 3/2 moist) ill-defined blocky, gritty sandy loam with probably a higher content of silt and clay than in the layer above; slight to medium acidity.	5-8"
16-26"	Light grayish-brown (2.5Y 5.5/2 dry) to yellowish-brown (2.5Y 5/4 moist) loose gritty loamy sand; massive or single-grained; only slight coherence or stickiness; slightly acid.	10-14"
26-44"	Pale yellow (2.5Y 7.5/4 dry) to light yellowish-brown (2.5Y 6/4 moist) coarse sand and gravel; loose and incoherent; slightly acid to neutral.	12-20"

Some of the gravel and fragments show moderate to strong weathering and are easily broken. The underlying materials are imperfectly stratified. Abundant mica flakes below horizon one.

The soils are somewhat darker at the higher than at the lower elevations as a rule. In places the upper part of the subsoil is a loam and has a slight stickiness. Where they join the Bass and Charlos soils their line of separation is not sharply defined. Some areas contain only a few stones of cobble-stone size. The topography consists of broad sloping fans with a gradient of 4 to 10 per cent toward the master streams. Steeper short slopes occur at the edges of the fans and between different levels of the fans. The soils are well to excessively drained, except as they develop temporary water tables during periods of heavy irrigation. The vegetation consists of grasses common to the region, some shrubs and open stands of pine."

The Blodgett soils are only moderately productive but no extensive fertilizer program has been carried out in the area. There has not been a noticeable response to light applications of barnyard manure or fairly heavy applications of gypsum and lime according to reports from local farmers. Oat yields of 40-50 bushels per acre and mixed hay yields of ¼ to 1 ton per acre are frequently obtained on this soil. It is also rather difficult to establish and maintain stands of alfalfa and Red clover.

The following study of the fertility status of Blodgett sandy loam was undertaken in an attempt to acquire the necessary preliminary information to set up comprehensive fertilizer tests in the area and to attempt to bring the productivity of this soil up to a level comparable with that of the soils on the east side of the Bitterroot Valley.

In order to obtain this preliminary information it was decided to conduct a series of greenhouse fertility tests in conjunction with a chemical analysis of the soil and to place preliminary fertilizer tests in the area concerned.

REVIEW OF LITERATURE

Blodgett sandy loam is a light-textured, porous, well to excessively drained, slightly acid soil formed mostly from granitic materials. It would therefore be expected to differ in many respects from other Montana soils.

There is a somewhat depressing effect on nitrogen fixation by symbiotic organisms at pH's lower than 6.0 according to Schreiner (12). Phosphorus is as a rule more available at a pH of 6.5-7.5 than at a lower or higher pH according to Pierre (10). Potassium is found in large quantities in most soils. Much of it, however, is tied up in non-available forms and becomes available as the plants deplete the available fraction. Under heavy rainfall or heavy irrigation, especially in the lighter textured soils, some of the available potassium is leached. The light textured soils, having a low exchange capacity, also tend to fix less potassium than do the heavier textured soils according to Joffe (7).

Cooper (5) found that soil areas in which the supply of magnesium is low are usually associated with regions of heavy precipitation and leaching. Light sandy loams in humid regions are apt to be low in magnesium. Heavy fertilization of these soils results in the addition of certain cations which form soluble salts with magnesium and thus favor its leaching. On both acid and alkali soils the colloids have become impoverished in calcium. In acid soils the calcium has been replaced by hydrogen, while in the alkali soils the calcium has been replaced by sodium. In both cases it is desirable to return calcium to its proper proportion of the soil complex.

Leeper (8) found that manganese is more available in soils with a pH lower than 6.0. At pH's lower than 6.0 the oxidized form of manganese, which is unavailable to plants, is readily reduced by the soil organic matter and becomes available. The oxidation of manganese to the unavailable form by soil organisms takes place rapidly at a pH of 6.0-7.5.

Though copper and zinc are classified as minor elements, a deficiency of these two elements can result in considerable crop losses. Deficiency of these two elements is usually restricted to light sandy soils.

Correction of the acidity of the light textured soils is best accomplished by liming. However, since many of the sandy soils have a low exchange capacity and also a low buffering capacity it is extremely important not to overlime. The beneficial effects of liming are many times nullified by the fixation of other elements due to overliming. When setting up a liming program it is advisable to take the following factors into consideration.

The most favorable reaction range for nitrification lies between pH 6 and 8. The nitrous and nitric acids after being formed are soon neutralized by exchangeable Ca or $CaCO_3$. The most favorable reaction for the availability of phosphorus is between pH 6.5 and 7.5. This is an important reason for liming acid soils to bring them up to a pH of 6.5. At strong acidity the condition for both accumulation of sulfur in organic matter and its transformation to sulfates for plant utilization is not favorable. Overliming tends to cause a manganese deficiency and it is also agreed that overliming produces a boron deficiency. Copper, zinc and iron seem to be most available between pH 5.7-6.2 according to Truog (14).

Wood (16) found that potassium becomes less available at pH's above 6.8. He also found that liming tends to fix large amounts of fertilizer potassium especially in the lighter textured soils.

No greenhouse or field fertility tests had been conducted on Blodgett sandy loam. Neither had this soil been given a detailed chemical analysis. The Agronomy and Soils Department at Montana State College has carried out a limited number of greenhouse and fertility tests on Bass sandy loam which is also found in the Bitterroot Valley and is similar to Blodgett, the main difference being in the color and texture of the subsoil (11). The Chemistry Department at Montana State College also ran a limited chemical analysis on this soil.

Greenhouse tests were carried out in the winter of 1945-46 using oats and alfalfa as test crops. The oats appeared to make the best response to a combination of nitrogen, phosphorus and gypsum, with the nitrogen and phosphorus combination doing nearly as well. The alfalfa seemed to make the greatest response to a combination of barnyard manure, phosphorus, and boron and the same elements with lime added were nearly equal in response. Minor elements other than boron were not studied.

The chemical analysis, although not complete, indicated that Bass sandy loam had a low content of total phosphorus and water-soluble boron. It was also low in organic matter and had a total nitrogen content of .092 per cent.

The results of the greenhouse tests indicated that for oats a combination of nitrogen and phosphate fertilizer was needed for best results and that boron might be deficient. The results also indicated that alfalfa would very likely be benefited by an application of lime.

A field fertilizer test was placed on Bass sandy loam on the Oppeguard farm about 5 miles northwest of Hamilton, Montana in 1946. This test was conducted by the Agronomy and Soils Department at Montana State College in conjunction with the Soil Conservation Service. There was no visual response to the treatments and consequently the plots were not harvested.

MATERIALS AND METHODS

In connection with this study three greenhouse fertility tests and three field fertility tests were undertaken. These tests were supported by chemical analysis of the soil.

The soil for the greenhouse tests was obtained from the Henry Oppeguard farm about 5 miles northwest of Hamilton, Montana. The first soil was collected the latter part of September in 1949 from a plowed field which had grown oats. The soil was taken from the plow layer which was about 8 inches deep and taken to Bozeman, Montana where it was spread on a cement floor in the Agronomy Field House and allowed to dry. After it was air-dry, it was scooped back and forth several times until it was thoroughly mixed. It was then screened through a quarter inch screen to remove the stubble and stones and again thoroughly mixed.

The second sample of soil for the greenhouse tests was taken from the same field in April, 1950. Since Mr. Oppeguard had spread a light application of barnyard manure on the upper part of the field where the first sample was obtained, the second sample was taken from the lower or unfertilized part of the field. The soil was again taken from one area and to the same depth as the first sample. It was dried, screened and mixed in the same manner as the first sample.

Samples from three profiles were collected in October 1949 for chemical analysis. These were obtained by digging a large hole and taking the samples from a carefully trimmed side. Samples of each horizon were placed in paper bags. A description of the profile was recorded at the time of the sampling and the samples were then taken to Bozeman for laboratory analysis.

The first profile sample was taken from the same field as the soil for the greenhouse tests. This field is located in the SW$\frac{1}{4}$ of the SE$\frac{1}{4}$ of the SE$\frac{1}{4}$ of Section 10, Township 6N, Range 10 of Ravalli County. The field was in mixed hay from 1944-1948. The hay yielded about one ton per acre for three years and only three quarters of a ton the last year. In 1949 it was seeded to oats which yielded 50 bushels per acre. The field has had an occasional light top-dressing of barnyard manure and in both 1945 and 1946 300 pounds per acre of gypsum were applied. The farm has a good water supply in the early part of the season, but there is usually a shortage in August. Following is a description of this profile:

0-7" Sandy loam (10YR 5/2 dry); weak crumb structure, very friable.

7-13" Sandy loam (10YR 6/3 dry); ill-defined irregular blocky structure, crushing to crumb.

13-17" Sandy loam (10YR 6/3dry); poorly defined irregular blocky structure.

17-27" Strongly weathered granitic material, light sandy loam (10YR 5/2 dry); with color variations due to weathering; structureless.

27-40" About as above (10YR 5/2 dry); individual cobbles more readily discernable.

The second profile sample was taken from an undisturbed roadside about 150 feet east of the N$\frac{1}{4}$ corner of Section 4, Township 9, Range 20W. This location approached a virgin condition. Profile description follows:

0-7" Sandy loam (10YR 5/2 dry); moderately well developed crumb structure.

7-12" As above (10YR 6/3 dry); weakly developed blocky structure which crushed readily to crumb.

12-19" Sandy loam (10YR 7/3 dry); poorly defined, irregular blocky structure.

19-30" Strongly weathered granitic material, light sandy loam (10YR 7/6 dry); exhibiting color variation due to weathering.

30-40" As above (10YR 7/6 dry); with individual cobbles more easily distinguished.

The third profile sample was taken from a field of weedy, cultivated stubble land located in the NW$\frac{1}{4}$ of the SW$\frac{1}{4}$ of the SE$\frac{1}{4}$ of Section 26, Township 7N, Range 21W. This field was broken from sod in 1946 and has a relatively short water supply. The profile appeared as follows:

0-8" Sandy loam (10YR 5/2 dry); poorly defined crumb structure.

8-14" As above (10YR 6/3 dry); no well defined structure.

14-24" Weathered granitic material, loamy sand (10YR 7/3 dry); no well defined structure.

24-32" As above (10YR 7/3 dry); individual cobbles readily discernable.

Greenhouse Test No. 1

Since the greenhouse test with Bass sandy loam indicated a boron deficiency (11) and since a fast growing crop was desired, the first greenhouse test was set up with sunflowers as the test crop. Berger (1) found sunflowers to be a very good indicator crop for boron.

Two gallon, glazed, earthenware pots were used as containers in this test. They were filled with 20 pounds of air-dry soil. The experiment was set up as a randomized block with 18 treatments and 3 replications. More replications would have been desirable but lack of greenhouse space and the availability of pots limited the number of replications.

Since one objective of this test was to bring the productivity of this soil up to a level of some of the soils on the east side of the Bitterroot Valley, one pot of Burnt Fork sandy loam from the Horticulture Branch Station near Corvallis, Montana was placed in each replication. These pots were to be used in making yield comparisons with different treatments on the Blodgett sandy loam.

The fertility tests conducted on Bass sandy loam by Post (11) in 1946 indicated that a combination of N and P resulted in a greater response than did either N or P alone. With this as a basis, N and P were applied as a basic treatment to all pots except the check and the B and Bm treatments. For fertilizer treatments and rates of application in this study see Table I. The manure and the lime were thoroughly mixed in the upper 6 inches of the soil in the pots and the remaining fertilizers were then mixed in the upper two inches of the soil. Chemically pure materials were used in place of commercial fertilizers.

On January 7th, 12 Jupiter sunflower seeds were planted in each pot at a depth of about three quarters of an inch. The Jupiter is a semi-dwarf variety. The pots were then watered with tap water and were watered often enough to keep the surface moist but not heavily enough to cause leaching.

The seeds germinated well and all plants were up by January 14th. In order to compensate for differences in temperature and light intensity on the bench, the pots were rotated twice weekly in such a way that each pot occupied the same position on the bench only once during the experiment.