

Levels of Available Phosphate in Soils in Utah, Idaho, Washington, Montana and South Dakota as Shown by Soil Tests

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INTRODUCTION

During the past five years the Utah-Idaho Sugar Company, in cooperation with farmers throughout the area in which it operates, has conducted more than 350 field trials with commercial fertilizers. These trials were designed so as to determine the deficiency of both phosphorus and nitrogen.

Phosphate response in these field trials has varied greatly from one test field to another, and from one area to another. In many cases where phosphate deficiency was indicated it was not possible to determine in the field the degree of deficiency, due to the fact that many other factors at times become limiting or partially limiting factors.

Another disturbing factor in determining phosphate requirements through the use of field trials alone is the fact that it is not practical to conduct a field trial on every farmer's farm. Inasmuch as past cropping history and past fertilizer history makes each farm an individual problem, work was undertaken to check the results of soil analysis with the results of actual field trials, in the hope that the correlation would be close enough to make the use of soil tests a valuable supplement to field trials in making fertilizer recommendations.

The correlation of available phosphate tests and results from field trials was made by determining the available phosphate level on the unfertilized check plots of each field trial and correlating the phosphate level found with the yield increase obtained on plots receiving phosphate applications. After extensive comparisons over a period of two years, it was decided that soil tests could be used to supplement the data obtained from field trials, and an extensive soil sampling and soil analysis program was undertaken. This paper reports the results of soil samples analyzed from Utah, Idaho, Washington, Montana and South Dakota during 1949.

SOIL TESTING PROCEDURES

Obtaining the Soil Sample

All soil samples were taken by members of the Sugar Company field staff. The sample from each field tested was obtained by using a small soil sampling tube which could be pushed into the top 6 to 8 inches of soil. At least 12 small samples were obtained over the field area, and this soil was mixed thoroughly in a bucket. A composite sample of about 1.5 pounds of soil from each field sampled was sent to the local factory chemist to be air dried, sieved, and reduced to 100 grams by use of a Jones sampler. At regular intervals as sufficient samples were accumulated they were sent to the General Laboratory for analysis.

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Methods of Analyses

Apparatus, reagents, and procedures followed in making the analysis for available $P_{0.4}$ are outlined briefly below:

Apparatus

Electrophotometer with 650 filter or set at 650 millimicrons
Dense filter paper (E and D Folded paper No. 193, 15 cm.)
Lipped tumblers or 250 ml. beakers
125 ml. flasks
15 ml. pipettes
Special Burettes
Bulb dropper
500 ml. wide mouth bottles fitted with 2 hole stoppers and connecting tubes
Cylinder of CO_2 with reducing valve
Pulp balance

Reagents

Ammonium molybdate — dissolve 25 gm. of ammonium molybdate in 200 ml. distilled water at $60^\circ C$. Cool and filter. Dilute 280 ml. of cone. H_2SO_4 to about 750 ml. and cool. Pour the molybdate solution slowly with stirring into the acid solution. Cool and make up to 1 liter.

Stannous Chloride — Make up a 10% HCl solution by diluting 225 ml. cone. HCl to 1 liter. Dissolve 0.5 gm. of $SnCl_2 \cdot 2H_2O$ in 20 ml. of the 10% HCl . **This solution must be prepared fresh every day.**

Procedure

Add 250 ml. distilled water to each of not more than 6 wide mouth bottles. Then weigh on the pulp balance 50 gm. of soil into each bottle. Stopper the bottles with the solid stoppers and shake. Insert the train of connecting tubes so arranged that the inlet tubes reach within about 1/4 inch of the bottom of each bottle while the outlet tubes extend only slightly through the stoppers. Connect the inlet tube of the end bottle with the CO_2 and bubble a fairly brisk stream of gas through the six suspensions in series. Bubbling should not be so violent as to allow spray from one bottle to be carried into the next bottle by the CO_2 . Twirl the bottles several times to allow all the soil to come into contact with the carbonic acid. At the end of a 15-minute bubbling period remove the tubes, replace the solid stoppers in the same bottles they were used for the first shaking and shake. Filter immediately. Discard the first 1 to 20 ml. of filtrate. The filtrate must be perfectly clear. If it is not, refilter.

Pipette duplicate 15 ml. aliquots into 125 ml. flasks. Add 85 ml. distilled water, then add 4.4 ml. of molybdate solution. Balance the photometer using distilled water and 650 millimicron band. To the samples add exactly 10 drops of stannous chloride solution and swirl, allowing time to take a reading between each addition. Obtain the transmittancy exactly 5 minutes after adding the stannous chloride. Balance the instrument on the distilled water between the duplicates.

The amount of available phosphorus as PO_4 was determined from a curve prepared from a series of known standards. A blank determination on two of the standards was run twice each day.

ANALYTICAL RESULTS

Soil samples were taken during August, September and October of 1949 from fields which farmers indicated would go into beets in the spring of 1950. A total of more than 4500 soil samples was analyzed. The results of these analyses by factory district are shown in Table 1.

The available phosphate level varied greatly between districts. The phosphate level was highest in the Gunnison district in Utah, followed by the Toppenish factory district in Washington. The two lowest areas were the Chinook factory district in Montana and the Belle Fourche factory district in South Dakota.

Table 1.—Results of more than 4500 Soil Analyses for Available Phosphorus, Showing the Percentage of the Samples Falling into Each of the Available Phosphate Groups. Available Phosphate Level is Expressed in P.P.M.* of PO_4 .

District	0-5 P.P.M.	6-10 P.P.M.	11-15 P.P.M.	16-20 P.P.M.	21-25 P.P.M.	Over 25 P.P.M.
Gunnison, Utah	5	19	16	15	11	34
West Jordan, Utah	20	26	16	12	7	9
Garland, Utah	29	32	19	8	5	7
Idaho	22	27	18	10	9	14
Washington	11	22	18	15	10	26
Montana	65	19	6	3	3	6
South Dakota	68	20	6	2	1	3
Nebraska	31	31	27	3	5	3

*P.P.M. is symbol used for parts per million.

Within any one of the districts, available phosphate levels varied from as low as 2 parts per million to in excess of 100 parts per million. This extreme variation provided an opportunity to check the available phosphate levels with the level of crop production and with the record of past fertilizer practice. In every instance, high available phosphate level occurred on farms where farmers were applying phosphate fertilizer to both sugar beets and alfalfa. On the other hand, the extremely low phosphate levels were found on farms where there had been little or no past use of commercial fertilizer carrying phosphate. Low phosphate level was generally associated with areas and farms where the nitrogen level was known to be low, and as a consequence either the low phosphate level or the low nitrogen level, or both, were responsible for low levels of crop production.

In many other cases nitrogen level was low but phosphate level was high. In these cases farmers had been making annual application of treble superphosphate but had ignored the nitrogen supply. In these cases the high phosphate level so aggravated the nitrogen deficiency that additional applications of phosphate fertilizer not only gave no yield response but in many cases actually decreased yields.

In correlating the available phosphate level with field tests, many cases were encountered where phosphate applications alone gave no yield response, even though the soil analysis showed the phosphate level to be

extremely low. In almost every one of these cases nitrogen alone gave a response, and mixed fertilizer which supplied both nitrogen and phosphate produced a yield response which was much greater than that produced by either one of the elements applied alone.

These facts stress the importance of using mixed fertilizer in adequate amounts to supply both the nitrogen and phosphate requirements. Inasmuch as field tests have shown that in a great majority of cases minimum nitrogen requirements range from 45 to 60 pounds of nitrogen per acre, it readily becomes apparent that, if we use such mixed fertilizers as 12-15-0 or 16-20-0 or 15-11-0, then we must use a minimum of 300 to 400 pounds per acre.

The soil test used in conjunction with field trials and past cropping and fertilizer use history makes it possible to recommend more nearly the fertilizer ratio which is needed for maximum crop production.