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# THE SIGNIFICANCE OF CARBON DIOXIDE IN MAKING PHOSPHORUS AVAILABLE IN THE SOIL

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Various investigators (1) have shown that the soil atmosphere possesses a higher concentration of carbon dioxide when a legume is grown than when a non-legume is grown. The beneficial effects to crops following certain legumes have been attributed in part, at least, to the carbon dioxide evolved by the roots of the legumes. The significance of carbon dioxide in the soil air in breaking down minerals and making phosphorus available to plants is an important question from the practical standpoint.

An experiment was designed to measure the effects of carbon dioxide in making phosphorus available to plants. Carbon dioxide gas was added to the soils of one series and in carbon dioxide-saturated water, referred to as carbonic acid, in another series. One series received no carbon dioxide additions.

Carrington loam having a pH of 6.33 and a one-ton lime requirement was thoroughly mixed and placed in twelve four-gallon pots. Three pots were left untreated to serve as checks. Three pots were filled with soil treated with two-tenths per cent straw. The soils of three pots were treated with two-tenths per cent straw and two hundredths per cent rock phosphate. Three pots were filled with soil treated with two tenths per cent of straw, two hundredths per cent of rock phosphate and enough lime to neutralize the acidity.

The soil of one pot of each of these sets received no carbon dioxide. Carbon dioxide gas was added from below to the soil of one pot of each set at the rate of five liters per hour for one hour each day throughout the experiment. The flow of carbon dioxide gas was regulated and measured by means of flow meters. Carbonic acid was added to the soil of one pot of each set. The experiment was run for five months and the moisture content of the soil was kept at twenty per cent during this period by the addition of distilled water. Soil samples were taken the first of November and the first of each month thereafter, including April. The first samples were taken before the soils were treated. Available phosphorus was measured by the Truog method (2) which consists of

shaking two grams of soil with 400 cc. of 0.002 normal sulfuric acid for thirty minutes. The phosphorus is then determined by the Deniges colorimetric method. The results obtained are shown in table I.

The check soil showed very little change in available phosphorus over the period of five months. A decrease in available phosphorus was found in the soil to which straw was added. It is possible that the decomposing straw released some phosphorus but it is also likely that this phosphorus was assimilated by the increased numbers of microorganisms. At any rate, the analyses show a decrease in available phosphorus.

In the soil treated with straw and rock phosphate there was a continuous increase in available phosphorus during the first four months. Rock phosphate in the soil under field conditions is usually

*Table I — The Effect of Carbon Dioxide on the Availability of Phosphorus in Soil*

| Soil | Date of Sampling | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | Check | Carbon dioxide gas | | Carbon dioxide solution | |
| | | p.p.m. P | p.p.m. P | Percent Increase | p.p.m. P | Percent Increase |
| Untreated soil | Nov. | 19.23 | 19.23 | | 19.23 | |
| | Dec. | 18.33 | 19.41 | 5.88 | 21.51 | 17.35 |
| | Jan. | 17.85 | 19.23 | 7.72 | 19.61 | 9.86 |
| | Feb. | 17.24 | 19.37 | 12.35 | 18.23 | 5.74 |
| | March | 17.87 | 21.13 | 18.24 | 23.43 | 31.12 |
| | April | 18.24 | 23.86 | 30.81 | 20.00 | 9.64 |
| | Average | 17.90 | 20.60 | 15.08 | 20.55 | 14.74 |
| Soil + Straw | Nov. | 19.23 | 19.23 | | 19.23 | |
| | Dec. | 16.12 | 20.88 | 29.52 | 19.61 | 21.65 |
| | Jan. | 13.51 | 20.00 | 48.03 | 21.33 | 57.88 |
| | Feb. | 15.87 | 20.00 | 26.02 | 22.43 | 41.34 |
| | March | 15.88 | 19.67 | 23.86 | 20.00 | 25.94 |
| | April | 16.66 | 18.75 | 12.54 | 23.46 | 40.80 |
| | Average | 15.60 | 19.85 | 27.30 | 21.36 | 36.92 |
| Soil + Straw + P | Nov. | 19.23 | 19.23 | | 19.23 | |
| | Dec. | 24.19 | 37.04 | 53.12 | 41.68 | 72.22 |
| | Jan. | 28.06 | 38.51 | 37.24 | 38.48 | 37.13 |
| | Feb. | 32.60 | 37.59 | 15.30 | 38.54 | 18.22 |
| | March | 36.51 | 43.48 | 19.09 | 41.08 | 12.52 |
| | April | 30.96 | 37.95 | 22.57 | 35.71 | 15.50 |
| | Average | 30.46 | 38.91 | 29.46 | 39.09 | 28.34 |
| Soil + Straw + P + Lime | Nov. | 19.23 | 19.23 | | 19.23 | |
| | Dec. | 34.09 | 41.78 | 22.55 | 41.68 | 22.26 |
| | Jan. | 28.99 | 35.08 | 21.01 | 47.61 | 29.73 |
| | Feb. | 33.33 | 39.00 | 17.01 | 42.37 | 27.12 |
| | March | 35.41 | 42.00 | 18.61 | 46.25 | 30.61 |
| | April | 34.88 | 37.53 | 17.59 | 43.61 | 25.02 |
| | Average | 33.34 | 39.07 | 17.19 | 42.30 | 26.95 |

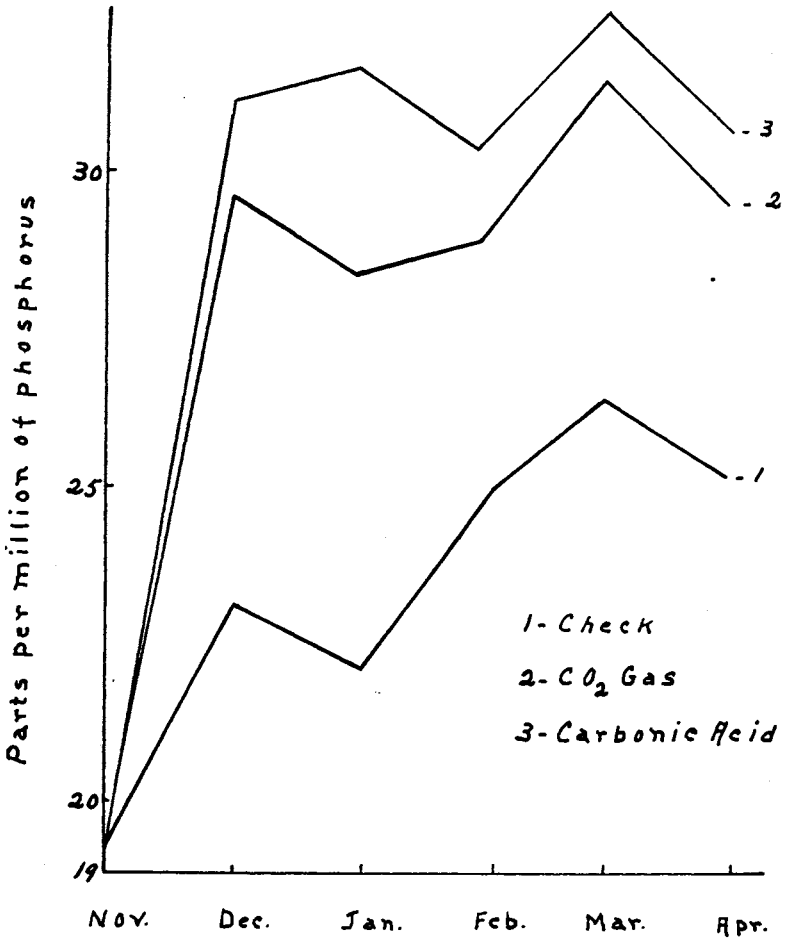


Fig. 1. Influence of $CO_2$ on the solubility of phosphorus in soil.

slowly available to plants and the application of rock phosphate often brings about greater effects the second year than the first. The results here showed about ninety-five per cent increase in the available phosphorus when applied with straw.

Lime in addition to straw and rock phosphate gave an increase of 9.45 per cent in available phosphorus. These results indicate no depression of available phosphorus due to the lime.

The addition of carbon dioxide as a gas to the soil gave an average of 15.08 per cent increase in available phosphorus over that in the soil receiving no carbon dioxide gas. This indicates that carbon dioxide in the soil air increases the availability of soil phosphorus. When straw was applied there was a slight decrease in

available phosphorus, probably brought about by an increased assimilation by microorganisms decomposing the straw. Rock phosphate added with the straw showed a large increase in available phosphorus. An increase of 53.12 per cent was obtained the first month over that in the soil which was not treated with carbon dioxide. The soil which received the lime in addition to straw and phosphorus showed no decrease in available phosphorus. An average increase of 0.41 per cent was obtained over that present in the soil receiving the same treatment except that no lime was added.

The soil which received carbonic acid alone showed an average increase of 14.74 per cent in available phosphorus over the soil to which no carbon dioxide was added. The soils treated with straw and carbonic acid contained about the same amount of available phosphorus as the soil without the addition of straw. However, more available phosphorus was present in this soil than in the same soil with the carbon dioxide gas treatment. In the soil treated with rock phosphate and straw there was an increase of 72.22 per cent in available phosphorus during the first month. The soil treated with carbonic acid showed more available phosphorus than the corresponding soil treated with carbon dioxide gas. In the soil which received lime in addition to straw and rock phosphate an increase of 22.26 per cent in available phosphorus over the check soil was found the first month. An average increase over the unlimed soil of 8.21 per cent in available phosphorus was obtained. The results were plotted and are shown in figure 1.

Each curve shows a general increase in available phosphorus with the increase in time after the additions were made. The greatest increase in the amount of available phosphorus from the addition of carbon dioxide was obtained the first month. The soils subjected to carbonic acid treatment over the period of the experiment were higher in available phosphorus than those subjected to any other treatment.

The results of these experiments seem to warrant the following conclusions:

1. Carbon dioxide is an active force in the soil which causes the decomposition of phosphate minerals making the phosphorus available to plants.
2. Carbonic acid treatments gave greater effects on phosphorus availability than the addition of the gas.
3. Lime did not decrease the availability of phosphorus and hence does not cause a reversion of phosphorus.

4. While straw alone may depress the availability of the native phosphorus in the soil when the additions of rock phosphate are made, it brings about a great increase in the availability of the added phosphorus.

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