Crop Response to Fused Tricalcium Phosphate

Lloyd F. Seatz, Samuel L. Tisdale, and Eric Winters

FUSED tricalcium phosphate is a fertilizer material prepared by defluorinating phosphate rock by melting it with silica in a fuel-fired furnace. The material is then quenched in water and ground to the desired particle size. Fused tricalcium phosphate was manufactured in quantity by the Tennessee Valley Authority from June 1945 until July 1954 to obtain information on operating efficiency of furnaces of different designs, on economics of the process, on agronomic value of the material and on other points of interest to potential commercial producers of the product. The details of manufacture, as well as a discussion of the chemistry of this material, have been thoroughly covered in several publications (4, 6, 8, 10).

Fused tricalcium phosphate produced by TVA contains less than 0.4% fluorine and about 28% total P₂O₅. The product contains practically no water-soluble P₂O₅, but analysis of material ground to pass a 150-mesh sieve indicates about 20 to 24% P₂O₅ soluble in neutral ammonium citrate. The material has excellent handling qualities and can be stored in bulk in the open without affecting either its physical or chemical properties. No sulfuric acid is required in the production of fused tricalcium phosphate. This might provide an important economic advantage for fused tricalcium phosphate, should the price of sulfuric acid increase significantly.

It is the purpose of this paper to review briefly some of the published information showing crop response to fused tricalcium phosphate and, in addition, to present data available in TVA files from field tests conducted at various locations in the United States since 1941. Fused tricalcium phosphate has been compared with other materials on the basis of total rather than citrate-soluble P₂O₅, except where noted. The material supplied to the experimenters by TVA has had approximately the chemical composition stated above. The mechanical analysis of the -10 and -40 mesh materials used indicates the following average size distribution of particles: 98 and 99% through a 10-mesh screen; 50 and 90% through a 40-mesh screen; and 5 and 40% through a 100-mesh screen, respectively.

The following abbreviations will be used throughout the paper for convenience in referring to the several fertilizer materials that are considered:

1. CSP: Concentrated superphosphate, 45 to 48% P₂O₅.
2. SP: Ordinary superphosphate, 16 to 20% P₂O₅.
3. FTP-6, -10, -40, -80: Fused tricalcium phosphate passing through a U. S. screen of a mesh equal to the number indicated.

**REVIEW OF LITERATURE**

Published data from field and greenhouse experiments indicate that responses to Fused tricalcium phosphate vary with conditions under which the fertilizer is used. Among the factors that affect the effectiveness of FTP are: (1) availability of other essential nutrients such as potassium and nitrogen; (2) crop; (3) fineness of grinding of FTP, and (4) concentration of FTP. The results of studies of these factors are given in the following sections.

**Soil Reaction**

In general, FTP has proved less effective than CSP on alkaline soils. Ross and Jacob (22), reporting results of a collaborative greenhouse test involving 15 agricultural stations, concluded that FTP was as effective as CSP on phosphate on soils having pH values of less than 7.14 but was less effective on more alkaline soils. The phosphorus used in these tests was ground to -80 mesh, and the content was not stated. It was produced in a pilot furnace in the TVA demonstration scale plant. Baker (24) reported that FTP was inferior to the growth of alfalfa on the alkaline soils of Idaho. In some cases the application of FTP did not increase yields of alfalfa above those obtained on the no-phosphate treatments. Rhoades (18) found that FTP was much less effective than CSP for wheat on certain alkaline soils of Nebraska and South Dakota. Van Scoy and Rhoades (24) reported no significant differences in the effectiveness and availability of FTP in greenhouse experiments involving soybeans and alfalfa. However, FTP was slightly less effective than CSP on the small-grain crops. In several greenhouse tests involving corn and soybeans, FTP was consistently lower in effectiveness than CSP. Ensminger (7) also presented data on field experiments in which FTP gave about the same yields of cotton, corn, oats, winter legumes, and Sudangrass, respectively, compared to 100 for CSP. Hazelwood (14) reported results of studies conducted in Ohio in which soybeans were used as the test crop; data on FTP and CSP applied at equal rates of citrate-soluble P₂O₅ and worked into the soil before seeding produced about the same yield increases during a 3-year experimental period. O'Brien (16) reported results of tests conducted in Virginia. These tests included a wide range of crops grown in rotations common to the various sections of the state. He found an average increase in yield of 25% for FTP, while the yield increase from CSP was 32%. O'Brien concluded that FTP was, in general, not as effective as CSP under the conditions of their experiments.

The conflicting results reported in various trials of FTP as a source of phosphorus for crops suggest that several factors may be involved which affect the availability of FTP. Of these factors have been investigated. They are: (1) variations in the chemical composition of the material; (2) differences in the physical properties of the material; (3) differences in the amount of sulfuric acid used in the production of the material; and (4) differences in the time of application of the material.