# Nutritive Value of Nitric Phosphates Produced from Florida Leached-Zone and Land-Pebble Phosphates Determined in Greenhouse Culture

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**Processes for producing nitric phosphate offer a means for utilizing low grade phosphate material, called leached-zone ore, that occurs in Florida land-pebble deposits. Because the nitric phosphate produced therefrom carries a much larger amount of aluminum than that made from commercial Florida land pebble, nutritive tests were made in the greenhouse, in order to determine the relative value of the high-alumina nitric phosphate. Crop yields and phosphorus uptakes showed that the leached-zone nitric phosphate had a lower agronomic value than the land-pebble material, when both had a low proportion of phosphorus in the water-soluble form. At medium levels of water solubilities, however, both products and triple superphosphate gave comparable yields.**

The agronomic evaluation of nitric phosphate (also known as nitrophosphate and nitraphosphate) either as NP or NPK products has been conducted at several locations in Europe and the United States. Rogers (*8*) compiled results from 10 state agricultural experiment stations and concluded that the phosphorus in the nitric phosphates was as effective as that in concentrated superphosphate to corn, cotton, and small grain on acid soils in the southeastern United States. He also concluded that 10% water solubility of the phosphorus in nitric phosphates was ample for acid soils of that area, whereas higher water solubility was desirable for alkaline soils of Iowa and Nebraska. The optimal granule size range for these products was indicated to be 12 to 50 mesh.

Thorne, Johnson, and Seatz (*9*) reported the results of 130 field experiments in which nitric phosphates were evaluated under field and greenhouse conditions in 11 states. The phosphate in most nitric phosphates was as effective for cotton, small grains, and corn as phosphate in commercial-type fertilizer mixtures or in concentrated superphosphate. For vegetable crops they concluded that the nitric phosphates should have a third or more of the phosphate present in a water-soluble form.

Cooke (*3*), in summarizing field experiments carried out in the United Kingdom and Holland, indicated that nitric phosphates generally had between one half and three quarters of the efficiency of superphosphates. The experiments in both countries show that these materials tend to be most efficient on acid soils and less efficient on neutral soils. Mulder (*7*) reported that pot and field experiments in The Netherlands showed nitric phosphate to be less effective than superphosphate when the materials were applied in the spring. Increase in content of water-soluble phosphorus or decrease of granule size enhanced the effectiveness of the phosphate. On alkaline soils, both the direct and residual phosphorus effects were considerably less than on slightly acid soils.

Byckowski and Ostromecka (*2*) conducted pot tests with nitric phosphates in Poland on a coarse ferrous sandy soil, acid sandy soil, neutral clay soil, and peat soil high in calcium carbonate. Pulverized nitric phosphates were generally equivalent to superphosphate. Granulation of nitric phosphate decreased the agronomic effectiveness of the phosphorus, especially on soils high in calcium or in mobile ferrous compounds.

The agronomic value of nitric phosphate from leached-zone ore, a low grade phosphate material cast aside as waste in current mining practice in the Florida land-pebble district, has not been determined. However, aluminum is a principal constituent of these products, and the nutritive value of aluminum phosphates has been studied. Truog (*10*) found that corn utilized precipitated aluminum phosphate rather well in quartz cultures. The yield of plant material, however, was considerably lower than that grown with superphosphate. Bartholomew and Jacob (*1*) grew Sudan grass in the greenhouse on an acid Clarksville silt loam (Arkansas) fertilized with several phosphates. The relative efficiencies, in comparison with monocalcium phosphate as 100, were 81 and 94 for ignited and nonignited precipitated aluminum phosphates, respectively, and 107 and 43 for ignited and nonignited natural aluminum phosphates.

Toxicity of aluminum to plants in acid soils has been reported by Hartwell and Pember (*4*) and McGeorge (*5*). McLean and Gilbert (*6*) grouped several crops according to their sensitivity to aluminum toxicity, as follows: lettuce, beets, timothy, and barley, sensitive; radishes, sorghum, cabbage, oats, and rye, medium sensitive; corn, turnips, and redtop, resistant. Wright and Donahue (*11*) reported that this apparent toxicity was the result of the precipitation of phosphorus by aluminum within the roots of the plant and a consequent interference with the normal phosphorus metabolism of the plant. In any event the amount of aluminum added in leached-zone nitric phosphates, even at the highest probable rates of application, is very small in comparison with that already present in the soil.

Apart from toxicity effects, the presence of aluminum and iron phosphates in the leached-zone products in amounts sufficient to account for a substantial part of the total phosphorus could, as far as previous experiments show, result in a lowered nutritive value of the phosphorus. In order to provide specific information on this agronomic aspect of nitric phosphates, the two types of product were compared in greenhouse culture at two levels of phosphorus solubility in water under conditions that prevented, as far as possible, growth limitation by lack of nutrients other than phosphorus.

## Fertilizer Materials

The composition of the test phosphates is shown in Table I. The leached-zone nitric phosphates differ mainly in amount of water-soluble phosphorus and rep-

**Table I. Composition of Nitric Phosphates and Superphosphate**

| Lot Number TVA | Lot Number SWC | Source and Nominal Grade | Sample[a] | Particle Size, Tyler Mesh | Percentage Composition: N | $P_2O_5$ Total | $P_2O_5$ Available | $P_2O_5$ Water-soluble[b] | $K_2O$ | CaO | Cl | $Al_2O_3$ | $Fe_2O_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 3194 | Leached-zone nitric phosphate, 15-15-15 | A | −12, +50 | 15.1 | 15.1 | 14.8 | 4.0 | 15.0 | 5.2 | 10.3 | 5.6 | 0.9 |
| | | | B | −14, +20 | 14.7 | 14.9 | 14.6 | 6.7 | 14.4 | | | | |
| 123 | 3196 | Land-pebble nitric phosphate, 14-14-14 | A | −12, +50 | 14.3 | 14.7 | 14.3 | 4.8 | 14.9 | 12.9 | 11.4 | ... | ... |
| | | | B | −14, +20 | 14.0 | 14.4 | 13.9 | 8.3 | 14.2 | | | | |
| 51-1 | 3186 | Leached-zone nitric phosphate, 11-22-11 | A | − 6, +40 | 11.4 | 23.6 | 23.1 | 19.9 | 11.8 | 4.7 | 8.8 | 9.6 | 1.3 |
| | | | B | −14, +20 | 10.8 | 23.3 | 22.8 | 21.0 | 11.2 | | | | |
| 45 | 3192 | Land-pebble nitric phosphate, 12-23-11 | A | −12, +50 | 12.1 | 23.5 | 22.6 | 27.7 | 11.7 | 15.0 | 9.2 | 0.6 | <0.1 |
| | | | B | −14, +20 | 12.0 | 22.5 | 21.6 | 28.4 | 11.3 | | | | |
| | 3032 | Land-pebble triple superphosphate, 0-48-0 | .. | −28 | 0 | 50.0 | 48.8 | 88.0 | 0 | 22.5 | ... | ... | ... |

[a] Sample B was screened from material A (as received). Only B samples were used in growth tests.
[b] % of total $P_2O_5$.

resent a low and a moderately low level of phosphorus water solubility (less than 10% and 20 to 30% of the total phosphorus, respectively). The land-pebble nitric phosphates were selected from available materials with a view toward approximating as closely as possible the phosphorus water solubilities of the leached-zone products. The nitric phosphate materials used in the tests were 14- to 20-mesh fractions (Samples B) separated from the materials received from the producer. Land-pebble triple superphosphate was used as a standard of comparison. Supplemental nitrogen and potassium were supplied by ammonium nitrate and potassium chloride. Minor elements, including boron, manganese, copper, zinc, and molybdenum, were applied in solution.

### Soils

The morphological and chemical characteristics of the soils are given in Table II. The Evesboro loamy sand had a very low content of extractable phosphorus and a low base exchange capacity. The Chester silt loam was also very low in phosphorus, but its base exchange capacity was about four times greater than that of the Evesboro soil. The lime requirements were determined in the laboratory in terms of pounds of calcium carbonate equivalent required per 2,000,000 pounds of soil to bring the soils to pH 6.0. Half of the requirement was supplied by calcium hydroxide and half by magnesium oxide. The pH of the Evesboro and Chester soils at planting time was 6.3 and 5.8, respectively.

### Culture Preparation and Management

The soils were limed on March 27, 1954, brought to moisture equivalent, and permitted to equilibrate for 19 days. On April 15, 1954, the moist soil was sieved, and then the fertilizers were mixed throughout the soil. Although the rates of phosphorus application varied, the nitrogen and potassium applied were constant for all cultures of any one soil. The nitrogen and potassium oxide rates in pounds per acre (area basis) were 200 each on the Evesboro soil and 300 and 400, respectively, on the Chester soil. Ammonium nitrate and potassium chloride, the only sources of nitrogen and potassium used with superphosphate and no-phosphorus cultures, were added as a supplement to the nitrogen and potassium of the nitric phosphates until the chosen levels of these nutrients were attained. Perennial rye grass was planted and minor elements were added in solution on the same day that the cultures were fertilized. The cultures were then brought to moisture equivalent and in order to maintain the moisture near this level, the cultures were weighed about twice a week throughout the growing season. Three replications of the phosphorus treatments and six replications of the no-phosphorus treatments were used.

A few days prior to the second cutting a visible nitrogen deficiency appeared in most cultures of the Evesboro soil. Determination of nitrogen and potassium in selected plant material from the first and second cuttings indicated that most of the nitrogen and a considerable amount of potassium originally applied had been used by the plants. Thus, an additional application of 200 pounds of nitrogen per acre as ammonium nitrate and 100 pounds of potassium oxide per acre as potassium chloride were added in solution to all cultures 5 days after the second cutting. This treatment corrected the nitrogen deficiency.

The first cutting of the crop was made on May 25, 1954, 40 days after planting. The second and third cuttings were made after growth periods of 23 and 25 days, respectively. The dry-weight yield was determined by drying the cuttings in

**Table II. Morphological and Chemical Characteristics of Soils Used**

| Sample No. | Soil Type and Origin | Great Soil Group | Original pH | Lb. $P_2O_5$/Acre Soluble in 0.05M $NaHCO_3$ | 0.002N $H_2SO_4$ | Exchangeable Cations, Meq./100 Grams Soil: Ca | Mg | K | Na | H | Sum | Base Saturation, % | Organic Carbon, % | Moisture Equivalent, % | Lime Requirement[a], $CaCO_3$ | pH at Planting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52383 | Evesboro loamy sand, Beltsville, Md. | Red yellow Podzolic | 4.8 | 22 | 17 | 0.9 | 0.1 | 0.1 | 0.2 | 1.9 | 3.2 | 41 | 0.53 | 7.7 | 1,250 | 6.3 |
| 51609 | Chester silt loam, Sandy Springs, Md. | Gray brown Podzolic | 5.2 | 22 | 20 | 3.9 | 0.4 | 0.1 | 0.1 | 9.7 | 14.2 | 32 | 1.35 | 25.4 | 2,000 | 5.8 |

[a] Pounds of $CaCO_3$ equivalent per 2,000,000 lb. of soil.

**Table III. Oven-Dry Weight of Three Cuttings of Rye Grass**

(Grams per culture)

| SWC No. | Source and Nominal Grade | Water-Soluble $P_2O_5$, % of Total | $P_2O_5$ Applied, Lb./Acre | Evesboro Loamy Sand: First cutting | Second cutting | Third cutting | Sum | Chester Silt Loam: First cutting | Second cutting | Third cutting | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3194 | Leached-zone nitric phosphate, 15-15-15 | 6.7 | 50 | 3.63 | 4.30 | 3.59 | 11.52 | 2.21 | 3.07 | 2.34 | 7.62 |
| | | | 100 | 3.93 | 4.83 | 3.87 | 12.63 | 2.79 | 3.72 | 3.39 | 9.90 |
| | | | 200 | 4.83 | 4.44 | 5.71 | 14.98 | 3.99 | 5.76 | 4.28 | 14.03 |
| 3196 | Land-pebble nitric phosphate, 14-14-14 | 8.3 | 50 | 3.71 | 4.34 | 4.05 | 12.10 | 2.80 | 4.16 | 3.03 | 9.99 |
| | | | 100 | 5.24 | 4.28 | 4.10 | 13.62 | 4.25 | 6.17 | 4.24 | 14.66 |
| | | | 200 | 5.45 | 4.18 | 4.72 | 14.35 | 5.32 | 6.49 | 5.39 | 17.20 |
| 3186 | Leached-zone nitric phosphate, 11-22-11 | 21.0 | 50 | 4.03 | 4.65 | 4.03 | 12.71 | 2.33 | 3.47 | 3.03 | 8.83 |
| | | | 100 | 4.81 | 4.41 | 4.86 | 14.08 | 3.94 | 5.55 | 3.85 | 13.34 |
| | | | 200 | 5.33 | 4.58 | 5.54 | 15.45 | 4.85 | 6.99 | 5.44 | 17.28 |
| | | | 400 | 5.98 | 4.30 | 5.86 | 16.14 | 6.00 | 7.29 | 6.51 | 19.80 |
| 3192 | Land-pebble nitric phosphate, 12-23-12 | 28.4 | 50 | 4.24 | 4.35 | 4.61 | 13.20 | 2.61 | 4.13 | 3.23 | 9.97 |
| | | | 100 | 5.05 | 4.32 | 4.42 | 13.79 | 3.84 | 5.98 | 3.72 | 13.54 |
| | | | 200 | 5.89 | 4.30 | 5.36 | 15.55 | 5.02 | 6.98 | 5.96 | 17.96 |
| | | | 400 | 6.48 | 4.31 | 5.76 | 16.55 | 5.66 | 7.07 | 6.42 | 19.15 |
| 3032 | Land-pebble triple superphosphate, 0-48-0 | 88.0 | 50 | 4.29 | 4.25 | 4.46 | 13.00 | 2.41 | 3.76 | 2.92 | 9.09 |
| | | | 100 | 5.37 | 4.19 | 5.25 | 14.81 | 3.90 | 5.81 | 4.43 | 14.14 |
| | | | 200 | 5.96 | 4.17 | 5.87 | 16.00 | 5.21 | 7.16 | 6.91 | 19.28 |
| | | | 400 | 6.45 | 4.03 | 5.76 | 16.24 | 5.47 | 6.98 | 7.26 | 19.71 |
| | No phosphorus | | 0 | 2.24 | 3.32 | 2.83 | 8.39 | 0.66 | 1.33 | 1.12 | 3.11 |
| Least significant difference, grams | | | | | | | | | | | |
| 1% level | | | | 0.72 | 0.78 | 1.13 | 2.04 | 1.78 | 1.44 | 1.32 | 2.02 |
| 5% level | | | | 0.59 | 0.58 | 0.85 | 1.53 | 1.34 | 1.08 | 0.99 | 1.51 |

a forced-draft oven at 65° C. The plant material was then ground, ashed, and analyzed for phosphorus. Statistical analyses of the yield and phosphorus uptake data were performed for each cutting as well as the sums of the three cuttings. Although the statistical comparisons do not comprise an orthogonal set, they seem to be the most logical ones for this study.

### Rye Grass Response to Nitric Phosphates

The oven-dry weights of the three rye grass cuttings are presented in Table III. Phosphorus uptake is given in Table IV.

**Table IV. Phosphorus Uptake by Three Cuttings of Rye Grass**

(Milligrams per culture)

| SWC No. | Source and Nominal Grade | Water-Soluble $P_2O_5$, % of Total | $P_2O_5$ Applied, Lb./Acre | Evesboro Loamy Sand: First cutting | Second cutting | Third cutting | Sum | Chester Silt Loam: First cutting | Second cutting | Third cutting | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3194 | Leached-zone nitric phosphate, 15-15-15 | 6.7 | 50 | 16.4 | 16.9 | 12.1 | 45.4 | 8.9 | 16.1 | 9.3 | 34.3 |
| | | | 100 | 21.6 | 20.9 | 15.0 | 57.5 | 11.4 | 20.6 | 14.7 | 46.7 |
| | | | 200 | 32.8 | 29.0 | 30.6 | 92.4 | 21.8 | 31.2 | 19.2 | 72.2 |
| 3196 | Land-pebble nitric phosphate, 14-14-14 | 8.3 | 50 | 20.0 | 17.8 | 19.0 | 56.8 | 12.1 | 23.1 | 15.5 | 50.7 |
| | | | 100 | 31.0 | 20.1 | 21.0 | 72.1 | 19.2 | 32.9 | 25.1 | 77.2 |
| | | | 200 | 46.1 | 25.7 | 25.4 | 97.2 | 28.4 | 36.3 | 28.6 | 93.3 |
| 3186 | Leached-zone nitric phosphate, 11-22-11 | 21.0 | 50 | 19.6 | 17.1 | 16.8 | 53.5 | 9.5 | 16.0 | 10.8 | 36.3 |
| | | | 100 | 28.2 | 21.6 | 23.1 | 72.9 | 17.8 | 31.5 | 12.8 | 62.1 |
| | | | 200 | 39.1 | 32.6 | 31.4 | 103.1 | 25.4 | 39.3 | 19.0 | 83.7 |
| | | | 400 | 54.5 | 40.9 | 39.6 | 135.0 | 36.2 | 42.6 | 33.0 | 111.8 |
| 3192 | Land-pebble nitric phosphate, 12-23-12 | 28.4 | 50 | 20.5 | 17.5 | 20.1 | 58.1 | 11.0 | 21.2 | 12.3 | 44.5 |
| | | | 100 | 30.6 | 20.8 | 21.5 | 72.9 | 17.5 | 34.7 | 19.3 | 71.5 |
| | | | 200 | 47.3 | 30.7 | 32.7 | 110.7 | 28.8 | 38.9 | 30.8 | 98.5 |
| | | | 400 | 65.5 | 44.6 | 42.8 | 152.9 | 36.9 | 47.9 | 37.4 | 122.2 |
| 3032 | Land-pebble triple superphosphate, 0-48-0 | 88.0 | 50 | 21.4 | 18.1 | 18.0 | 57.5 | 9.3 | 19.6 | 11.8 | 40.7 |
| | | | 100 | 33.7 | 23.5 | 21.9 | 79.1 | 14.5 | 33.0 | 18.6 | 66.1 |
| | | | 200 | 52.9 | 38.8 | 36.9 | 128.6 | 25.9 | 43.2 | 33.7 | 102.8 |
| | | | 400 | 84.7 | 52.3 | 58.0 | 195.0 | 33.9 | 49.6 | 39.8 | 123.3 |
| | No phosphorus | | 0 | 8.0 | 13.1 | 12.0 | 33.1 | 1.8 | 6.3 | 5.8 | 13.9 |
| Least significant difference, mg. | | | | | | | | | | | |
| 1% level | | | | 9.9 | 6.5 | 9.3 | 22.5 | 9.5 | 10.6 | 11.9 | 17.3 |
| 5% level | | | | 7.4 | 4.9 | 6.9 | 16.9 | 7.1 | 7.9 | 8.9 | 13.0 |

**Table V. Levels of Significance[a] between Sources of Variation in Rye Grass Responses**

| Source of Variation | Soil Type: Evesboro Loamy Sand — Yield, G./Pot, for Cutting 1 | 2 | 3 | Sum | Uptake, Mg. $P_2O_5$/Pot for Cutting 1 | 2 | 3 | Sum | Chester Silt Loam — Yield, G./Pot, for Cutting 1 | 2 | 3 | Sum | Uptake, Mg. $P_2O_5$/Pot for Cutting 1 | 2 | 3 | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Nitric phosphate and superphosphate (all cultures) | | | | | | | | | | | | | | | | |
| 1. Blocks | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| 2. Treatments | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3. Rates (0–200 lb. $P_2O_5$ per acre) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4. Materials | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5. Rates X materials | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | 1 | 1 | NS | NS | NS | 1 |
| B. Nitric phosphates only (50–200 lb. $P_2O_5$ per acre) | | | | | | | | | | | | | | | | |
| 1. Leached zone *vs.* land pebble, all cultures | 1 | NS | NS | NS | 1 | NS | NS | 5 | 5 | 1 | 5 | 1 | 1 | 1 | 1 | 1 |
| 2. Leached zone *vs.* land pebble, <10% W.S. | 1 | NS | NS | NS | 1 | NS | NS | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3. Leached zone *vs.* land pebble, 20–30% W.S. | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | 5 | 1 |
| 4. <10 *vs.* 20–30% W.S., all cultures | 1 | NS | 1 | 1 | 5 | NS | 5 | 5 | NS | 1 | 5 | 1 | NS | 5 | NS | NS |
| C. Nitric phosphate (20–30% W.S. only) and superphosphate | | | | | | | | | | | | | | | | |
| 1. Rates (0–400 lb. $P_2O_5$ per acre) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2. Materials | 1 | NS | NS | NS | 1 | 1 | 1 | 1 | NS | NS | 5 | NS | NS | NS | 1 | 1 |
| 3. Leached zone *vs.* land pebble | 5 | NS | NS | NS | 1 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | 1 |
| 4. Nitric phosphate *vs.* superphosphate | 5 | NS | NS | NS | 1 | 1 | 1 | 1 | NS | NS | NS | NS | NS | NS | NS | NS |
| 5. Rates × materials | NS | NS | NS | NS | 1 | 1 | 1 | 1 | NS | NS | NS | NS | NS | NS | NS | NS |

[a] NS, 1, and 5 indicate nonsignificance, significance at 1% level, and significance at 5% level, respectively.

Levels of significance between sources of variation are summarized in Table V. Differences due to materials and rates of application were highly significant for the experiment as a whole (Table V, A-3 and 4).

**Yield.** The leached-zone products as a group gave significantly lower yields than the land-pebble materials for all cuttings on the Chester soil and for the first cutting on the Evesboro soil (Tables III and V, B-1). However, the lower yields are attributable mainly to the leached-zone product at the low water-solubility level (Table V, B-2 and 3). Nitric phosphates in the low-solubility category gave significantly lower yields (total harvest) on both soils than those having a higher water solubility (Table V, B-4). Significance for the Chester soil, however, is attributable to the very poor showing of the leached-zone product of low solubility (Table III). On the other hand, the nitric phosphates with 20 to 30% of the phosphorus in the water-soluble form gave yields comparable with those of triple superphosphate on both soils (Table V, C-4).

**Phosphorus Uptake.** The phosphorus uptake (Tables IV and V) substantiated all of the differences observed with the yield data. Some differences not disclosed by yield are noteworthy. Although yield differences (total harvest) between nitric phosphates in the low range of solubility were not obtained on the Evesboro soil, uptakes were significantly different and the leached-zone product gave lower uptake. Similarly, nitric phosphates in the higher range of solubility showed significant uptake differences on Chester soil, and again the leached-zone product gave lower uptake. The phosphorus uptake from triple superphosphate was greater than that from any of the nitric phosphates at all cuttings on Evesboro soil. This was particularly significant at higher rates of application.

## Conclusions

Considering crop yield and phosphorus uptake as criteria for the agronomic value of the fertilizers used in this experiment, nitric phosphates with less than 10% of the phosphorus in the water-soluble form were less effective than those with medium solubilities (20 to 30%). At the low water solubility level the leached-zone product had a lower agronomic value than the land-pebble material, whereas at medium water solubilities the products were comparable. The nitric phosphates with medium water solubilities gave crop yields comparable to those of triple superphosphate. Thus, in this experiment, water solubility of the nitric phosphate was a more important source of variation than the type of phosphate ore from which the product was prepared.

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