Solution Rate of Complete Granular Fertilizer under Field Conditions

Rapid dissolution of nutrients from a granular fertilizer in contact with soil was experimentally verified under tropical field conditions. From a cornfield, normally sown and fertilized, samples of granules were taken after increasing time intervals. The first sample, with 90 minutes of soil contact, showed that more than 60% of the N and water-soluble P, and about 40% of the K originally present, had migrated into the soil. The analysis 24 hours after sowing showed that more than 90% of the N and water-soluble P and 80% of the K had left the granules.

The amount of each element which left fertilizer granules when used under normal field conditions was evaluated. Through chemical analysis and density determinations of granules removed from soil after increasing time intervals, the dissolution rate was determined.

The Société Saint-Gobain (1952) studied the dissolution of a granular fertilizer in the field after 10, 20, and 30 days, but the granules were not in total contact with the soil. Muller (1954) determined the dissolution of N, P, K, and Cl in a granular fertilizer after 24 hours and after 6 days of soil contact, but the experiment was made in a laboratory. Under laboratory conditions Lawton and Vomocil (1954) verified that 50 to 80% of water-soluble P moved out of the granules of superphosphate in 24 hours.

EXPERIMENTAL

Materials. The experiments were carried out in the northeast region of São Paulo, Brazil. The soil consists of clay 38.4, silt 10.4, fine sand 14.2, and coarse sand 37.0%. The pH was 4.6. Moisture content was 19.6, field capacity 24.5, and wilting point 10.8%.

Fertilizing and sowing were started on the morning of November 12, 1966. Four kilograms of 4–7–5 fertilizer per 100-meter row were employed. The fertilizer consisted of 200 kg. of ammonium sulfate, 600 kg. of normal superphosphate (11.2% total P, 10.4% available P), 100 kg. of Florida ground rock phosphate (16.2% P), and 100 kg. of potassium chloride, granulated in an Eirich inclined pan granulator.

Soil temperature was 22° C., increasing to 24° C. at midday. In the afternoon, 8.5 hours after sowing, 20 mm. of rain fell; during the first week, 100 mm. more.

Samples. Ninety minutes after sowing, the first sample was taken. The manual picking of the granules took 20 to 30 minutes. They were immediately freed from the adherent soil, vacuum-dried, and classified by sieving (Table I). The "fines" were discarded.

The method employed relies on the determination of the soluble nutrients remaining in the volume unit of the granules after increasing time intervals in the soil. So the whole or undamaged recovery of the granules is not essential. Although we tried to choose the most perfect ones, theoretically the same results should be obtained with broken or eroded granules.

Determinations. Chemical analyses were made by AOAC methods (1965). The densities were determined by mercury buoyancy by the method of Pocharkoff *et al.* (1967). The samples were analyzed separately according to their size classification, but the results were tabulated (Table I) as a mixture in the initial volume ratio of the three sizes.

Density determinations of the small original granules gave results 15 to 20% lower than those obtained with medium and large granules. This discrepancy was surmounted by dipping the fertilizer into the mercury, previously heated at 100° C., and determining the density in the usual manner after cooling to room temperature. This indicates that the small original granules with their larger specific surface do not have sufficient internal empty space to receive their surface-retained air when compressed by the mercury during immersion at room temperature, thus giving lower density results. The original fertilizer granules, despite their appearance, are porous: Their density is 1.7 grams per ml., whereas for the same material after crushing, 2.2 grams per ml. (pycnometer with xylene) were found, meaning that there is about 0.23-ml. empty space per ml. of granule volume.

DISCUSSION

For complete knowledge of the fertilizer action it is fundamental to determine the localization of the soluble components of the fertilizer in the system fertilizer-soil-water-plant during the whole crop cycle.

This paper contributes to the understanding of the first phase of the process: the time taken by the soluble nutrients to move out of the granules which appear as skeletons after the end of the crop cycle.

In a cornfield normally cultivated, more than 50% of the nutrients had left the granules after only 2 hours; 24 hours after fertilizing more than 90% of the N and water-soluble P, and about 80% of the K originally present, had passed to the soil. In 5 days, just as the corn shoots were emerging from the soil, the granules had lost all their nutrient value and remained in the soil, until the end of the crop cycle, as residual granules without fertilizing value. Of course, the above results were found under humidity and temperature conditions favoring rapid dissolution, but these are normal in this climate and season.

Table I. Reduction of Constituents by Dissolution of Fertilizer in Soil

Time, Hours	Density, G./Ml.			Reduction, %					Insoluble P, G./100 Ml. Fertilizer
	L[a]	M[a]	S[a]	Nitrogen	Total P	Available P	Water-soluble P	K	
0	1.68	1.64	1.60	...	...	...	...	...	3.59
1.5	1.37	1.37	1.28	66.3	36.6	52.0	67.6	45.4	3.51
2.5	1.31	1.30	1.23	70.1	40.4	55.6	70.7	51.8	3.45
4.0	1.23	1.21	1.10	78.9	48.3	64.1	82.1	58.1	3.28
10.0[b]	1.18	1.22	1.06	87.5	53.2	80.5	91.2	62.4	4.26
24.0	1.12	1.18	0.94	94.2	57.0	79.5	94.5	82.4	3.67
72.0	1.09	1.08	1.05	98.0	55.7	74.0	94.5	93.4	3.32
120.0	1.11	1.07	1.03	98.0	59.3	78.7	97.3	98.9	3.29
170.0	1.06	1.04	1.06	98.0	57.3	81.1	97.3	97.9	3.78
720.0	1.07	1.00	0.93	98.4	60.8	80.2	97.5	99.0	3.25

[a] Screen analysis of original fertilizer.

L. Large size (−5.66 + 4.00 mm.), 13.4% by weight.
M. Medium size (−4.00 + 2.38 mm.), 34.0% by weight.
S. Small size (−2.38 + 1.41 mm.), 28.3% by weight.
Fine material (−1.41 mm.), 24.3% by weight.

[b] 20 mm. of rain.

The influence of the size of the granules on the extraction rate of nutrients was restricted to the first hours; 2.5 hours after fertilizing 45.0% of available P had left the large granules, while 59.0% had left the medium granules, and 62.3% had left the small granules. But after 4 hours of soil contact, the small granules had the same composition as the larger ones.

The amounts of insoluble phosphorus in the residues of the granules remained almost constant for periods up to 720 hours (a month) in soil (Table I). The amount present throughout this period corresponded to that added as Florida rock phosphate (3.5 grams of P per 100 ml. of fertilizer). These results show that rock phosphate did not dissolve from the granules, even at pH 4.6. Sayre and Clark (1938) found some reversion of water-soluble P in granules kept in contact with a neutral soil (pH 6.9) for 2 to 52 weeks. Practically all the water-soluble P in our experiments left the granules so rapidly that none remained as a reversion product inside the granules.

There are numerous publications comparing the effectiveness of granulated with dry mixed fertilizers, but the results are not uniform. When both types of fertilizers are applied in rows, the results are similar (Cook *et al.*, 1957; Lawton and Cook, 1955).

If granular fertilizers distributed in soil dissolve rapidly, forming high nutrient concentration zones near the granules, and when the granulate distribution is in the form of high density rows, these zones would intermesh with each other, forming an almost homogeneous concentration zone alone the row, similar to the one obtained from dry mixed fertilizers.

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Received for review October 18, 1967. Accepted July 1, 1968