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*In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).

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ASSOCIATION INTERNATIONALE
DES FABRICANTS DE SUPERPHOSPHATE (I.S.M.A.)

COMITÉ AGRONOMIQUE

1 Avenue Franklin D. Roosevelt, Paris 8e

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JOINT TECHNICAL AND AGRICULTURAL MEETING

LAUSANNE (Switzerland) - Monday 24th - Thursday 27th September, 1956.

PA/152

Subject : 1 c

DETERMINATION OF THE P_2O_5-UPTAKE FROM POWDERED AND GRANULATED SUPERPHOSPHATE BY MEANS OF P^{32}, by A. FRUHSTORFER (Germany)

The germinating plant derives its phosphoric acid requirements from the seed, but, when the formation of chlorophyll sets in, the plant has to rely upon the phosphoric acid extracted from the soil. In view of the inadequate root-formation it is, as yet, difficult for the plant to dissolve and assimilate the phosphoric acid fixed in the soil. During its early stages of growth, therefore, the plant has to depend upon the presence of readily soluble fertiliser P_2O_5. Later, with a more robust root-system, the phosphoric acid in the soil can be solubilised and assimilated to a greater degree.

In the past it was hardly possible to separate these processes and to study them individually. In fertiliser experiments, the total phosphoric acid was determined after harvesting, the increase in uptake by the fertilised plots being compared with the quantity of phosphoric acid applied. In these experiments the proportion of phosphoric acid derived from fertilisers was determined; this rarely exceeded 15% and usually remained considerably below this figure.

By determining and examining yields at successive stages of growth it is, however, possible to follow the uptake of phosphoric acid. In no instance, however, is it possible to ascertain the proportion of phosphoric acid extracted from the soil or that of the P_2O_5 absorbed from the fertiliser.

Only by the application of phosphorus rendered radio-active by artificial means, has it been possible to separate and to study more closely the process of phosphoric-acid fertilisation with different phosphates, with varying degrees of fineness, with different methods of application and with varying times of application. In the following, it is proposed to examine the effect of granular superphosphate compared with powdered super. It is generally accepted that the effect of a fertiliser salt depends upon its degree of fineness and its distribution in the soil. This, no doubt, applies to nitrogen and potash. With phosphates, however, different laws come into play. Soluble phosphates tend to produce homogenous soil solutions by diffusion in the soil and during this process encounter substances for which they have a pronounced affinity. They are precipitated and remain insoluble thereby reducing their assimilability by the plant. Water-insoluble fertiliser phosphates, however, are gradually solubilised by the carbonic acid in the soil and by the acid secretions of the roots, thus enabling the plant roots to absorb the phosphoric acid before the process of solubilisation is reversed by the soil complex. Water-soluble phosphates, therefore, are more at a disadvantage than at an advantage on acid soils and on soils with a pronounced power of fixation.

Auto-radiographs of a fertilised soil profile demonstrate that powdered superphosphate penetrates into the soil more or less evenly, first with solubilised, then with precipitated phosphate, whilst with granulated fertilisers, the phosphoric acid is precipitated only in the immediate vicinity of the granules. Apart from the portions devoid of fertiliser phosphate, accumulations are to be found in the soil which are tantamount to an excessive phosphoric-acid fertilisation in the soil strata under observation. This excessive fertilisation prevents the phosphate - which was originally water-soluble - from becoming insoluble and useless and a comparatively large proportion of the phosphoric acid in these accumulations remains available to the roots. Hence, the assimilability of the phosphoric acid in water-soluble phosphates is improved by granulation. Matters are different with water-insoluble phosphates. In this case, the phosphate component remains in the granule, thereby offering too limited a surface to the water containing carbonic acid and to the plant roots in search of phosphate. The availability is diminished and for that reason the granulation of all phosphates which are not water-soluble is inadmissible.

Scharrer and Kühn have demonstrated the effect of powdered and granulated superphosphate in a pot experiment conducted in 1955. Maize was selected as an experimental crop, the phosphoric acid being marked by the radio-active isotope P^{32}. Each week the yield of a maize pot was taken and the phosphoric-acid uptake determined in the ash. Thus, it was possible to measure separately the uptake of the total phosphoric acid and of the fertiliser phosphoric acid, the latter being ascertained by measuring radio-active radiation. Although an exact evaluation was impossible owing to the lack of repeated experiments the tendency of the figures gives a clear and uniform picture. The results were as follows:

Yields and uptake of phosphoric acid (per pot)

		Yield g	Total %	Total P_2O_5 mg	Fertiliser %	Fertiliser P_2O_5 mg	Rel.
1st experimental yield	powd.	0,23	13.13	3.0	0.14	0.03	100
	gran.	0.30	13.46	4.0	0.16	0.05	166
2nd d.o	powd.	3.20	6.08	19.5	0.58	1.86	100
	gran.	2.85	5.75	16.4	0.68	1.94	104
3rd d.o	powd.	5.80	4.58	26.6	0.78	4.52	100
	gran.	6.15	4.94	30.4	0.98	6.03	133
4th d.o	powd.	10.80	3.42	36.9	1.18	12.7	100
	gran.	12.25	3.65	44.7	1.76	21.6	170
5th d.o	powd.	15.60	3.18	49.6	1.16	18.1	100
	gran.	19.10	3.37	64.4	1.67	31.9	176
6th d.o	powd.	32.4	2.76	89.4	1.21	39.2	100
	gran.	30.9	2.96	91.5	1.70	52.5	134
7th d.o	powd.	44.1	2.75	121.3	1.24	54.7	100
	gran.	44.6	2.68	119.5	1.45	64.7	118
8th d.o	powd.	52.5	2.59	136.0	1.08	56.7	100
	gran.	56.8	2.29	130.1	1.39	79.0	139
9th d.o	powd.	63.3	2.56	162.0	1.18	74.7	100
	gran.	70.9	2.07	146.8	1.02	72.3	97

The results are conclusive in more than one way. It is demonstrated that more than half of the total phosphoric acid contained in a plant has been taken up from the soil whilst the remainder originated from the fertiliser. In the case of granular superphosphate, however, the proportion of fertiliser phosphoric acid rose to more than 50%. In these experiments the minute quantities of phosphoric acid contained in the seed, which play an important role in the first stage of growth, have been ignored. It was further shown that from the very first days the uptake and effect of the phosphoric acid of the granular superphosphate exceeded that of the powdered super. During the 3rd, 4th and 5th week more than 50% was taken up from the granular superphosphate than from the powdered super, and also during the later period of growth, the superiority of the granular superphosphate was very pronounced.

Towards the end of the experimental period an equalization could be observed. Plants had become sufficiently strong to be able to assimilate comparatively large quantities of phosphoric acid from the soil and from the fixed fertiliser phosphate, a phenomenon which we had been able to observe repeatedly in other experiments. The differences in the outer appearance of the plants "merge", i.e. the plants which previously had shown an appreciable difference in growth appear to be similar in growth. However, those plants which had been supplied with larger quantities of phosphoric acid during the early stages of growth bloomed at an earlier period and showed higher yields. This demonstrated that nourishment during the early steges had an important bearing on the later periods of growth.

This year we conducted several experiments in our own experimental station with the radio-active isotope P^{32}, the phosphoric-acid uptake by the living plant being determined by the method of Scheel. At the time of writing this report, the experiments are still being carried on until harvesting. Only a preliminary report on two experimental rows can be submitted in the following paragraphs relating to the phosphoric-acid uptake from powdered fertilisers mixed with the arable soil and from granular superphosphate applied in bands. Experiments were carried out with four repetitions so that in spite of the sources of error unavoidable when working with isotopes, the mean error could be confined to comparatively low limits.

Oats were used as an experimental crop. They were sown on March 20th on a sandy soil with a pH figure of 5.5. After germination, from April the 3rd onwards, the phosphoric-acid uptake was determined twice a week by measuring the radio-activity of the living plant. Altogether 18 readings were taken within a period of two months.

The following table (see page 4) was obtained up to June 1st:

+)	Powdered super applied to arable soil			Granular super applied in bands		
	1000 impulses per minute	m%	rel.	1000 impulses per minute	m%	rel.
3rd/IV	43.1 ± 2.7	6.28	100	9.8 ± 0.3	3.23	22.77
6th/IV	51.5 ± 3.3	6.45	100	26.0 ± 0.7	2.82	50.46
10th/IV	61.5 ± 2.6	4.25	100	32.1 ± 1.7	5.27	52.11
13th/IV	92.1 ± 6.0	6.52	100	43.8 ± 1.2	2.80	47.55
17th/IV	123.0 ± 4.8	3.92	100	63.1 ± 0.9	1.47	51.31
20th/IV	142.3 ± 6.7	4.70	100	86.8 ± 3.9	4.47	61.00
24th/IV	229.3 ± 10.0	4.38	100	197.2 ± 11.0	5.56	86.01
27th/IV	278.3 ± 6.1	2.18	100	248.5 ± 14.3	5.76	89.30
1st/V	308.9 ± 4.9	1.59	100	345.9 ± 19.3	5.57	111.97
4th/V	332.6 ± 5.6	1.70	100	472.5 ± 15.5	3.28	142.06
8th/V	358.8 ± 15.9	4.42	100	545.4 ± 15.9	2.92	152.03
11th/V	382.2 ± 2.7	0.70	100	588.8 ± 35.6	6.04	154.07
15th/V	420.7 ± 15.7	3.73	100	577.8 ± 14.3	2.47	137.36
18th/V	369.9 ± 4.3	1.18	100	544.5 ± 18.5	3.39	147.18
22nd/V	356.5 ± 5.4	1.53	100	505.3 ± 11.3	2.23	141.75
25th/V	365.4 ± 26.0	7.13	100	457.6 ± 10.1	2.21	125.22
29th/V	350.3 ± 3.3	0.93	100	458.4 ± 14.7	3.20	130.85
1st/VI	311.4 ± 20.5	6.60	100	412.4 ± 10.8	2.62	132.45

+) Date of measurement

We observe that in the first column with granular superphosphate the phosphoric-acid uptake is at first retarded, attaining the value in the column with powdered super only after four weeks. There is no doubt that this phenomenon is due to the application of the granules in bands by which means the roots of the young plants can only come into contact with the fertiliser at a later date. Exactly one month after germination, the pots with granular fertilisers showed better results than the row with powdered superphosphate, attaining the maximum uptake after six weeks. Then followed a stop in the uptake of fertiliser phosphoric acid in both rows, resulting even in a regression towards the end. As in the experiments described above, it may be assumed that the robust plants, which by now filled the entire pot with their root system, solubilised the phosphoric acid from the soil and the fixed phosphoric acid of the fertiliser in a comparatively high degree. As the total uptake of phosphoric acid was not determined in this experiment - this presupposes a premature harvesting of the plant and an examination of the ash - a comparison was not possible.

SUMMARY

The experiment conducted by Scharrer and Kühn, Giessen, and our own experiment with radio-active P^{32} demonstrated that the uptake of phosphoric acid from granular fertilisers was more rapid than from powdered material. During the decisive period of growth, the increase in uptake amounted to more than 50%. After two months this superiority diminished. The difference in the uptake of phosphoric acid was reflected by a correspondingly greater growth of the plants supplied with granular fertilisers.

APPENDIX to PA/152

DETERMINATION OF THE P_2O_5-UPTAKE FROM POWDERED AND GRANULATED SUPERPHOSPHATE BY MEANS OF P^{32}, by A. FRUHSTORFER (GERMANY)

Further details of the experiments show the influence of granulate superphosphate broadcast and distributed into the soil so that we can compare

row 1 powdered superphosphate distributed
row 2 granulated superphosphate distributed
row 3 granulated superphosphate layer.

The fractions of the granulation were as follows:

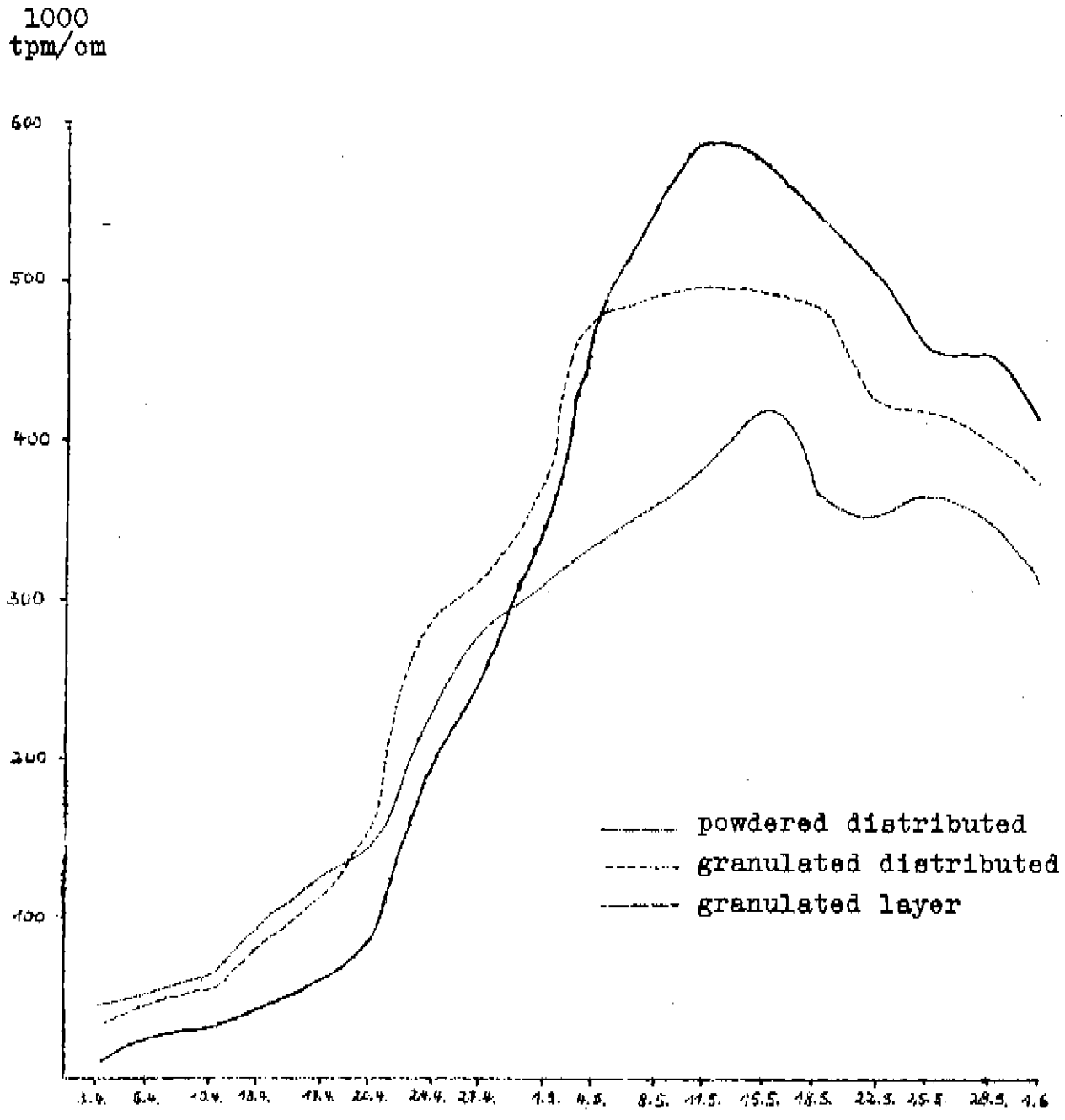
4 - 5 mm	3 - 4 mm	2 - 3 mm	1 - 2 mm
3,5%	14,0%	48,7%	33,8%

The following table shows the figures of the three test rows.

time of test	Superphosphate powdered distributed 1000 tpm+)/cm	m %	Superphosphate granulated distributed 1000 tpm+)/cm	m %	Superphosphate granulated layer 1000 tpm+)/cm	m %
3.4.	43,1 ± 2,7	6,3	32,2 ± 1,8	5,6	9,8 ± 0,3	3,1
6.4.	51,5 ± 3,3	6,4	46,8 ± 2,8	6,0	26,0 ± 0,7	2,7
10.4.	61,5 ± 2,6	4,2	56,7 ± 5,9	10,4	32,1 ± 1,7	5,3
13.4.	92,1 ± 6,0	6,5	86,0 ± 6,7	7,8	43,8 ± 1,2	2,7
17.4.	123,0 ± 4,8	3,9	117,1 ± 10,0	8,5	63,1 ± 0,9	1,4
20.4.	142,3 ± 6,7	4,7	156,2 ± 7,1	4,5	86,8 ± 3,9	4,5
24.4.	229,3 ± 10,1	4,4	288,4 ± 10,7	3,7	197,2 ± 11,0	5,6
27.4.	278,3 ± 6,1	2,2	316,0 ± 19,2	6,1	248,5 ± 14,3	5,8
1.5.	308,9 ± 4,9	1,6	377,0 ± 17,1	4,5	345,9 ± 19,3	5,6
4.5.	332,6 ± 5,7	1,7	478,3 ± 38,3	8,0	472,5 ± 15,5	3,3
8.5.	358,8 ± 15,9	4,4	490,8 ± 22,1	4,5	545,4 ± 15,9	2,9
11.5.	382,1 ± 2,7	0,7	- - -		588,8 ± 35,6	6,0
15.5.	420,7 ± 15,8	3,8	494,5 ± 20,8	4,2	577,8 ± 14,3	2,5
18.5.	370,0 ± 4,4,	1,2	488,5 ± 11,2	2,3	544,5 ± 18,5	3,4
22.5.	356,5 ± 5,5	1,5	424,6 ± 14,7	3,5	505,3 ± 11,3	2,2
25.5.	365,4 ± 26,0	7,1	421,8 ± 23,7	5,6	457,6 ± 10,1	2,2
29.5.	350,3 ± 3,3	0,9	402,7 ± 27,3	6,8	458,4 ± 14,7	3,2
1.6.	311,4 ± 20,5	6,6	376,2 ± 38,1	10,1	412,4 ± 10,8	2,6

It can be recognized that the uptake from powdered superphosphate is the best in the first two weeks. From then it is surpassed by row 2: granulated superphosphate which remains superior till the end of the experiment.

+) transmutations per minute



On the other hand, when applied in a layer 10 cm deep (row 3) the uptake is delayed by 3 weeks and after 5 weeks it is absolutely the best. The figures are about 13% higher than in row 2 and up to 50% higher than in row 1.

Relative figures

powdered superphosphate broadcast = 100

time of test	granulated broadcast	granulated layer	relative (granulated broadcast = 100
3.4.	74,7	22,7	30,4
6.4.	90,9	50,5	55,6
10.4.	92,2	52,2	56,6
13.4.	93,4	47,6	50,9
17.4.	95,2	51,3	53,9
20.4.	109,8	61,0	55,6
24.4.	125,8	86,0	68,4
27.4.	113,5	89,3	78,6
1.5.	122,0	112,0	91,8
4.5.	143,8	142,1	98,8
8.5.	136,8	152,0	111,1
11.5.	-	154,1	-
15.5.	117,5	137,3	116,8
18.5.	132,0	147,2	111,5
22.5.	119,1	141,7	119,0
25.5.	115,4	125,2	108,5
29.5.	115,0	130,9	113,8
1.6.	120,8	132,4	109,6