EFFECT OF HEAVY STORE DRESSING WITH ROCK PHOSPHATE ON A FINE SAND SOIL

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In a previous paper (Hänninen and Kaila 1960) results were reported of an attempt to study the possibilities of improving the soil phosphorus status by a store dressing with rock phosphate to such a degree that an annual application of superphosphate would no more be profitable. It was found in two field trials that 1000 kg/ha of rock phosphate was not enough to produce the effect wanted, and that even higher amounts than 2000 kg/ha may be recommendable under Finnish conditions. Therefore, a new field trial was started in 1960 by the late Dr. Pentti Hänninen, then the head of the agricultural experiment station in Central Finland, with applications of rock phosphate in quantities from 4000 to 12000 kg/ha. This trial has been continued for nine years. Part of the results are reported in the present paper. The primary yield results and the samples were provided in the first four experimental years by Dr. Hänninen, in 1968 by the present head of the experiment station, Mr Paavo Simojoki. The analytical work has been performed by the author.

Field trial

In the spring 1960 the following amounts of finely ground North African rock phosphate (Hyperphosphate) were applied to a fine sand soil:

1.	No phosphate		
2.	Rock phosphate	4000	kg/ha
3.	» »	8000	»
4.	» »	12000	»

Using the split plot technique, an annual dressing with 200 kg/ha of superphosphate was applied from 1961 to 1967. Basal dressings with nitrogen as ammonium nitrate limestone and with potassium as potassium chloride were used.

The test crop was barley in the first year, as a nurse crop of the red clover-timothy ley which grew for six years. In the last two years barley was grown.

For the main treatments, the plots harvested were 25 m², the area of subplots harvested was 14 m². Both the main treatments and the subtreatments within a block were randomized, and the whole experiment consisted of four blocks.

According to the manufacturer's analysis, the rock phosphate used contained 12.6 % P. The P content of superphosphate was on average 8.5 %. The rock phosphate was carefully worked in with plough and spade harrow. Superphosphate was applied as surface dressing to the ley.

Soil samples were collected in June 1960, or about four weeks after rock phosphate was applied, from successive layers of 2.5 cm down to the depth of 15 cm of all plots, and analysed separately. In 1968 soil samples were taken from the plough layer of all remaining 27 subplots: 5 subplots were at that time rejected because of disturbance caused by ditching.

Plant samples were collected at harvest from all plots or subplots in 1960—1963 and analysed separately. In 1968 grain samples were provided from all 27 remaining subplots, but only combined straw samples from the 8 subtreatments were available.

Analytical methods

Inorganic phosphorus in soil samples was fractionated by a somewhat modified method of CHANG and JACKSON (1957). Readily soluble phosphorus was estimated by extracting with 0.01 M $CaCl_2$ for 18 hours in the ratio of soil to solution of 1 to 5. Also the Bray 1 test and an acetic acid test were used. Soil pH was measured in a 1 to 2.5 suspension in 0.01 M $CaCl_2$.

Total phosphorus in plant samples was determined from ash solutions with the ammonium vanadate-molybdate method, total calcium and magnesium with versenate titration in 1960—1963, and with a Perkin Elmer Atomic absorption spectrophotometer 290 in 1968, and potassium with an EEL flame photometer. Total nitrogen was determined with the common Kjeldahl digestion.

The results were treated with DUNCAN's new multiple range test (DUNCAN 1955). Values marked by the same letter in the tables do not differ at the 5 per cent level.

Results

Years 1960—1963. The pH-values in Table 1 show that the calcium carbonate in rock phosphate has significantly decreased the acidity in all layers, most at the depth from 2.5 to 15 cm. The soil was not well buffered, since it was rather coarse textured and had a low humus content (2.1 % organic carbon).

In the previous trials (HÄNNINEN and KAILA 1960) rock phosphate was worked in only by spade harrow, and the soil analyses indicated that a large part of the fertilizer remained in the top layer of 0 to 7.5 cm. The more effective mixing with both plough

Table 1. pH in soil samples four weeks after the application of rock phosphate.

Depth	Rock phosphate kg/ha			
cm	0	4000	8000	12000
0 — 2.5	4.8^b	4.9^c	4.9^c	5.0^e
2.5— 5	4.7^a	4.8^b	4.9^c	5.1^f
5 — 7.5	4.7^a	4.9^c	5.0^e	5.1^f
7.5—10	4.8^b	4.9^c	5.0^e	5.2^g
10 —12.5	4.7^a	4.9^c	4.9^c	5.2^g
12.5—15	4.7^a	4.8^b	5.0^e	5.1^f

and harrow in the present trial distributed the fertilizer fairly well at least until the depth of 15 cm, as may be seen from Table 2.

Table 2. Fluoride-soluble and acid-soluble P fractions in soil samples four weeks after the application of 0, 4000, 8000, or 12000 kg/ha of rock phosphate.

Depth	Inorganic P ppm extracted by							
	NH_4F				H_2SO_4			
cm	0	4000	8000	12000	0	4000	8000	12000
0 — 2.5	33^{a}	53^{abc}	60^{abc}	66^{bc}	290^{d}	430^{de}	540^{de}	740^{fg}
2.5— 5	33^{a}	59^{abc}	59^{abc}	65^{bc}	290^{d}	480^{de}	610^{f}	880^{gh}
5 — 7.5	35^{ab}	62^{abc}	69^{c}	80^{c}	310^{de}	600^{f}	800^{fg}	1160^{hi}
7.5—10	35^{ab}	61^{abc}	62^{abc}	78^{c}	310^{de}	670^{fg}	760^{fg}	1180^{i}
10 —12.5	35^{ab}	59^{abc}	55^{abc}	80^{c}	300^{de}	580^{ef}	670^{fg}	1470^{j}
12.5—15	36^{ab}	60^{abc}	53^{abc}	72^{c}	290^{d}	590^{f}	560^{def}	930^{h}

In this table only the fractions of inorganic phosphorus extracted by ammonium fluoride and sulfuric acid are recorded, since no significant differences existed in the other fractions between the variously treated soils. The fertilizer phosphorus is found mainly in the acid soluble fraction which the heaviest application of rock phosphate has increased 2.5 to 5 times as compared to that of the untreated soil. The not very marked absolute increase in the fluoride soluble fraction brought about by rock phosphate is in accordance with the slow release of phosphorus from apatite, even in this relatively acid soil. The phosphorus content of the alkali soluble fraction ranged from 150 to 175 ppm, and these values did not statistically differ from each other. It seems that rock phosphate was accumulated particularly in the layers from 5 to 12.5 cm.

The average P-concentration in the $CaCl_2$-extract ranged from 0.03 mg/l in the 0—15 cm layer of the untreated soil to 0.05 mg/l in the plots treated with 8000 kg/ha of rock phosphate, and to 0.07 mg/l in the plots with the heaviest treatment. The mean values of the Bray 1 test were 27, 51, 59, and 66 ppm in the 0—15 cm layer in the plots which received 0, 4000, 8000, or 12000 kg/ha of rock phosphate, respectively. The corresponding average values of acetic acid-soluble P were 19, 105, 217 and 445 ppm, respectively. The

Table 3. Phosphorus in crops harvested in 1960.

Rock phosphate in 1960 kg/ha	P in barley				P in ley plants		Total P harvested kg/ha
	grain		straw				
	mg/g	kg/ha	mg/g	kg/ha	mg/g	kg/ha	
0	4.71^{a}	6.2^{a}	1.02^{a}	2.6^{a}	3.72^{a}	1.9^{a}	10.7^{a}
4000	5.02^{b}	6.7^{ab}	1.31^{b}	3.5^{b}	4.36^{b}	2.7^{a}	12.9^{b}
8000	5.34^{bc}	7.6^{b}	1.42^{b}	4.4^{c}	4.33^{b}	2.2^{a}	14.2^{bc}
12000	5.17^{bc}	7.6^{b}	1.43^{b}	4.0^{bc}	4.23^{b}	3.6^{b}	15.2^{c}

Means in each column followed by the same letter do not differ at $P = 0.05$.

highest test values were found in the layers from 5 to 12.5 cm of the plots treated with rock phosphate.

The crops of the first year, barley and the young ley, showed significant response to rock phosphate dressing according to the phosphorus content of the plants and the total uptake of phosphorus (Table 3). Because of the large variation, no statistically significant differences were found between the dry matter yields which were 1310 to 1480 kg/ha of barley grains, 2500 to 3130 kg/ha of barley straw, and from 510 to 860 kg/ha of dry matter from the ley. In all plant samples the phosphorus content has been increased by rock phosphate, although the heavier treatments have not usually been more effective than the lowest one. Yet, the total uptake of phosphorus by the crops harvested in the first growing season increases with the increase in the amount of rock phosphate applied. This increase was not marked, only 2.2 kg/ha by 4000 kg of rock phosphate, 3.5 kg/ha by 8000 kg, and 4.5 kg/ha by 12000 kg of rock phosphate.

During the following three growing seasons, the response of the ley plants to the rock phosphate store dressing was distinct (Table 4). There is some tendency to higher dry matter yields of hay with the increase in the amount of rock phosphate applied; because of the large variation typical of this trial, this increase is only seldom statistically significant. The annual surface dressing with superphosphate has not increased the dry matter yield, except in 1963 on the plots without rock phosphate.

Table 4. Hay yields in 1961—1963

Rock phosphate in 1960	Dry matter yield kg/ha		P in dry matter mg/g		P harvested in hay kg/ha	
kg/ha	0	Super	0	Super	0	Super
			In 1961			
0	4170^{a}	4400^{ab}	2.13^{a}	2.37^{b}	8.9^{a}	10.4^{b}
4000	4750^{c}	4640^{bc}	2.43^{bc}	2.70^{de}	11.5^{c}	12.5^{cd}
8000	4770^{c}	4720^{c}	2.65^{de}	2.58^{cd}	12.6^{d}	12.2^{cd}
12000	4900^{c}	4720^{c}	2.68^{de}	2.80^{e}	13.1^{d}	13.3^{d}
			In 1962			
0	6770^{f}	6750^{f}	2.21^{f}	2.45^{fgh}	14.9^{f}	16.5^{fg}
4000	7460^{g}	7180^{fg}	2.37^{fg}	2.61^{ghi}	17.7^{gh}	18.7^{ghi}
8000	7340^{g}	7300^{g}	2.56^{ghi}	2.69^{hi}	18.8^{ghi}	19.7^{hi}
12000	7410^{g}	7550^{g}	2.67^{ghi}	2.79^{hi}	19.8^{hi}	21.0^{i}
			in 1963			
0	4770^{j}	5420^{k}	1.49^{j}	1.65^{kl}	7.1^{j}	9.0^{k}
4000	6110^{l}	6220^{lm}	1.60^{jk}	1.74$^{k\ m}$	9.8^{kl}	10.8^{lm}
8000	6280^{lm}	6380^{lm}	1.71^{klm}	1.77^{lm}	10.8^{lm}	11.3^{m}
12000	6850^{m}	6470^{lm}	1.71^{klm}	1.83^{lm}	11.7^{m}	11.9^{m}

Means in the two corresponding columns »0» and »Super» followed by a common letter do not differ at P = 0.05.

On the other hand, superphosphate has in some cases had a positive effect on the phosphorus content of the hay. This is statistically significant in the ley without rock phosphate in 1961 and 1963, and also in 1961 with the rock phosphate store dressing of 4000 kg/ha. In the first year ley 4000 kg/ha of rock phosphate was enough to brought about a significant increase in the phosphorus content of hay, both with and without superphosphate; in the second year and third year leys 8000 kg/ha of rock phosphate was needed to produce this effect, if superphosphate was not applied. There is a marked tendency to an increase in the phosphorus content of hay with increasing amounts of rock phosphate in both halves of the plots.

The total amount of phosphorus harvested in hay from the rock phosphate plots was not significantly increased by superphosphate in any of these three years. The phosphorus yield tended to be the higher the heavier the rock phosphate store dressing was, even when superphosphate was applied.

The dry matter yield produced by the store dressing of 4000 kg/ha of rock phosphate was in all these three years significantly higher than that harvested from the plots which received only the annual application of 200 kg/ha of superphosphate. On the other hand, the phosphorus content of hay from these two treatments did not differ significantly in these years. The total uptake of phosphorus was by the first year ley crop higher from these rock phosphate plots than from these superphosphate plots, but in the second and third year the difference was no more significant.

The apparent recovery of rock phosphate phosphorus by the ley crops, calculated as the difference of the amounts harvested from the treated and untreated plots, were in the three years the following, expressed as P kg/ha:

	1961	1962	1963
Rock phosphate 4000 kg/ha	2.6	2.8	2.7
» » 8000 »	3.7	3.9	3.7
» » 12000 »	4.2	4.9	4.6

Thus the uptake of rock phosphate phosphorus is very low, and it remains at the same level from the respective treatments during all these years, and is of the same order as the uptake of rock phosphate phosphorus by the barley crop and the young ley crop in 1960. The annual application of superphosphate decreased, of course, the apparent recovery of rock phosphate phosphorus, though not markedly. In these three years the total recovery of 4000 kg/ha of rock phosphate was 8.1 kg/ha without superphosphate dressing and 6.1 kg/ha with it. The corresponding totals were 11.3 kg/ha and 7.3 kg/ha from 8000 kg of rock phosphate, and 13.7 kg/ha and 10.3 kg/ha from 12000 kg of rock phosphate.

In previous studies (Kaila and Hänninen 1960, Kaila 1969) it was found that the capacity of red clover to use rock phosphate phosphorus was distinctly higher than that of grasses in the same ley. In the present trial this difference appears to be less marked. The data in Table 5 show, however, that the heaviest dressing with rock phosphate has increased the phosphorus content of clover by 32 %, 25 % and 33 % as compared with the unfertilized clover in 1961, 1962, and 1963, respectively. The corresponding increases in the phosphorus content of grasses were 18 %, 10 %, and 10 %, respectively. Without rock phosphate, superphosphate increased the phosphorus content of both plants by 10—11 % in these years.

Table 5. Phosphorus content of clover and grasses

Rock phosphate in 1960 kg/ha	P mg/g in clover		P mg/g in grasses	
	0	Super	0	Super
In 1961				
0	2.19[a]	2.40[b]	2.07[a]	2.30[b]
4000	2.49[b]	2.81[c]	2.31[b]	2.54[c]
8000	2.85[c]	2.74[c]	2.41[bc]	2.41[bc]
12000	2.88[c]	2.89[c]	2.45[bc]	2.61[c]
In 1962				
0	2.20[d]	2.45[de]	2.22[d]	2.47[ef]
4000	2.38[de]	2.63[ef]	2.33[de]	2.56[fg]
8000	2.59[def]	2.70[ef]	2.43[ef]	2.65[fg]
12000	2.74[ef]	2.90[f]	2.45[ef]	2.51[efg]
In 1963				
0	1.59[g]	1.74[g]	1.47[h]	1.64[ij]
4000	1.77[g]	1.98[h]	1.56[hi]	1.69[ij]
8000	1.97[h]	2.11[h]	1.66[ij]	1.70[ij]
12000	2.11[h]	2.17[h]	1.62[i]	1.78[j]

Means in the two corresponding columns »0» and »Super» followed by a common letter do not differ at P = 0.05.

In spite of the positive effect of rock phosphate on the phosphorus content of red clover, there is in this trial no corroboration for the supposition that rock phosphate would be of use in the competition of clover with grasses in mixed leys. In each year, the percentage of clover in the hay was equal in all plots independent of the treatment, or averagely 58 % in 1961, 75 % in 1962, and 17 % in 1963.

The fertilizer treatments did not bring about any significant differences in the calcium, magnesium, or potassium contents of the clover and grass samples analysed. There was, however, some interesting effect of phosphates on the nitrogen content of both clover and grasses, most markedly in the hay of the first year ley. The following percentages of nitrogen were found:

	in clover 0	in clover Super	in grasses 0	in grasses Super
Rock phosphate 0	2.35[a]	2.89[b]	1.00[h]	1.26[i]
» » 4000 kg/ha	2.46[a]	3.06[b]	1.14[hi]	1.44[j]
» » 8000 »	2.91[b]	2.86[b]	1.26[ij]	1.17[hi]
» » 12000 »	2.94[b]	2.89[b]	1.33[ij]	1.36[ij]

The surface dressing with superphosphate has distinctly increased the nitrogen content of clover and grasses, when the store dressing with rock phosphate was 0 or 4000 kg/ha.

This may not be attributed only to the effect of sulphur in superphosphate, but it is likely to be due to a better phosphate nutrition, since also the higher applications of rock phosphate alone have produced equal increases in the nitrogen content of the plant samples.

Year 1968. The soil samples collected at the end of the experimental period in 1968 did not show any accumulation of superphosphate phosphorus, although the total amount applied in seven years was not insignificant, coming up to about 120 kg/ha of P. The effect of the store dressing with rock phosphate on the soil phosphorus analyses was also less marked than could be expected. It is likely that the ploughing of the soil after the last ley crop was harvested brought the surface layers with their fertilizer phosphorus to a deeper level than the sampling depth in 1968.

Table 6. Phosphorus fractions in the soil samples in 1968.

Rock phosphate in 1960 kg/ha	Inorganic P ppm extracted by					
	NH_4F		NaOH		H_2SO_4	
	0	Super	0	Super	0	Super
0	36^{a}	42^{ab}	163^{f}	158^{f}	311^{g}	297^{g}
4000	64^{bc}	80^{cd}	148^{f}	162^{f}	407^{gh}	397^{gh}
8000	95^{de}	84^{cde}	166^{f}	169^{f}	636^{ij}	541^{hi}
12000	95^{de}	99^{e}	157^{f}	158^{f}	694^{ij}	758^{j}

The results of the phosphorus fractionation of these samples are recorded in Table 6. No effect of fertilizers is found in the alkali-soluble fraction, representing iron bound phosphorus. The fluoride-soluble fraction supposed to be aluminium bound phosphorus or some lower calcium phosphates, is the higher the heavier the store dressing was, but the annual superphosphate applications have not significantly increased these values. The large variation hampers comparing of the results, particularly those of the acid-soluble or apatite-like phosphorus. Yet, the largest part of the rock phosphate recovered by these analyses appears to exist in the more or less unchanged apatite. The results of the phosphorus tests are in accordance with the fractionation data.

There was no indication of any effect of superphosphate either on the phosphorus content of the grain or on that of straw of the cereal in 1968. The phosphorus content of grains was 3.86 % without phosphorus fertilizers, and it increased with increasing amounts of rock phosphate up to 4.00 % on the plots with the heaviest dressing. Because of the large variation, this difference is not statistically significant. The straw samples contained from 1.01 to 1.33 % P quite independent of the amount of fertilizers applied during the experimental period. No differences were found in the nitrogen, calcium, magnesium, or potassium contents of these plant samples.

Discussion

In this acid fine sand soil crops responded to the heavy store dressing with rock phosphate, at least in the first four experimental years. From the second to the fourth year, the dry matter yield of red clover-timothy ley from the rock phosphate plots was not increased by the annual surface dressing with superphosphate. Superphosphate tended, however, to increase the phosphorus content of hay, though only in a few cases this increase was statistically significant.

The lowest amount of rock phosphate, 4000 kg/ha, was effective enough to produce higher dry matter yields than the annual superphosphate application alone, and the phosphorus content of hay was equal in both cases. The heavier store dressings, 8000 or 12000 kg/ha rock of phosphate, did no more increase the dry matter yields, but the phosphorus content of hay produced by them tended to be higher than that from the plots with 4000 kg/ha of rock phosphate.

It is of interest to note that the apparent recovery of rock phosphate phosphorus remained at the same levels in the first four experimental years, or it was, on an average, 2.6 kg/year from 4000 kg, 3.7 kg/year from 8000 kg, and 4.6 kg/year from 12000 kg. The application of superphosphate decreased these recoveries, but only slightly. The apparent recovery of superphosphate phosphorus when no rock phosphate was used was 1.5 to 1.9 kg/ha, or only about ten per cent in these three years.

The relatively efficient working down of rock phosphate was likely to improve its utilization and its reaction with the soil. In the first year samples the rock phosphate phosphorus was almost completely recovered by the fluoride and acid extractions of the fractionation procedure. In the samples collected at the end of the trial, the recovery was much poorer. This may be partly attributed to the large variation of the soil in the experimental area, and partly to the possibility that the surface layers with their fertilizer phosphorus were brought by ploughing down to a deeper level than the sampling depth in 1968. The latter possibility may be responsible also to the fact that no sign of the application of superphosphate during seven years could be detected by the soil analyses in 1968.

This fine sand soil seems to represent one of the extreme types of phosphate retention, or the soils which sorb applied soluble phosphorus almost completely by aluminium oxides and hydroxides, or as forms extractable by ammonium fluoride of the fractionation procedure (Kaila 1965). At least, no effect of fertilizers was found in the alkali-soluble fraction, supposed to be iron bound phosphorus and of a markedly lower availability than the fluoride-soluble phosphorus. Soils containing large amounts of active iron oxides and hydroxides are likely to sorb the slowly dissolving rock phosphate phosphorus so effectively that the response of crops to rock phosphate dressing may not be marked. In this soil 4000 kg/ha of rock phosphate seemed to be enough to improve the phosphorus conditions to such degree that the annual applications of superphosphate were no more profitable. In a soil of the opposite retention type, e.g. in a Litorina soil rich in iron, far larger amounts of rock phosphate may be needed. It is likely that even in soils in which the sorbed phosphate is more equally distributed between the aluminium and iron bound forms, very heavy applications of rock phosphate will not be the most profitable way to the improvement of their phosphorus conditions.

Summary

Results are reported of a long-term field trial on acid fine sand soil in which the effects of store dressing with rock phosphate in amounts of 0, 4000, 8000, or 12000 kg/ha was

studied comparing them with an annual application of 200 kg/ha of superphosphate using the split plot technique.

In the first four years, more thoroughly studied, the response to the store dressing with rock phosphate was distinct both in the dry matter yields and the phosphorus content of the cereal and the red clover-timothy hay. The differences between the various rates of rock phosphate treatments were not statistically significant, though there was some tendency to higher results with larger amounts of rock phosphate.

The annual applications of superphosphate as surface dressing to the ley did not brought about any significant increase in the dry matter yield of the rock phosphate plots, and although they tended to increase the phosphorus content of hay, the increase was statistically significant only in a few cases. No effect was found on the phosphorus content of barley grain and straw in the ninth experimental year.

No differences were found in the calcium, magnesium, or potassium content of the plant samples from the variously treated plots. Nitrogen content of clover and timothy was increased by both rock phosphate and superphosphate, particularly in the first year ley.

In this soil, 4000 kg/ha of rock phosphate was effective enough to produce higher dry matter yields of hay, with equal phosphorus content, than the annual application of 200 kg/ha of superphosphate. Soil analyses indicated that this soil represented the extreme pattern of phosphorus retention in which applied phosphate is almost completely retained as aluminium bound forms of the fluoride soluble fraction supposed to be fairly available. It was suggested that in soils which retain the slowly dissolving rock phosphate phosphorus mainly as less available iron bound forms, heavy applications of rock phosphate will not be a profitable way to improve the phosphorus conditions.

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SELOSTUS

VOIMAKKAAN HIENOFOSFAATTI-PERUSLANNOITUKSEN VAIKUTUKSESTA HIETAMAASSA

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Tutkimuksessa on esitetty osa Keski-Suomen koeaseman edesmenneen johtajan tohtori Pentti Hännisen kanssa aloitetusta kenttäkokeesta, jossa yritettiin selvittää, voidaanko antamalla hyvin suuria hienofosfaattimääriä varastolannoituksena parantaa maan fosforitilaa niin paljon, että vuotuinen superfosfaattilannoitus käy tarpeettomaksi. Hienofosfaattia annettiin v. 1960 huolellisesti maahan muokattuna 0, 4000, 8000 tai 12000 kg/ha ja seuraavasta vuodesta alkaen osaruutumenetelmää käyttäen 200 kg/ha superfosfaattia pintalannoituksena apila-timoteinurmelle.

Todettiin, että neljän ensimmäisen koevuoden aikana ohra ja nurmi antoivat pienimmällä hienofosfaatin määrällä selvän sadonlisäyksen, joka ei merkitsevästi eronnut suuremmilla määrillä saaduista, joskin kasviaineksen fosforipitoisuus näytti lisääntyvän lannoitemäärän mukana. Superfosfaatti ei lisännyt hienofosfaattia saaneiden ruutujen sadon määrää eikä merkitsevästi sen fosforipitoisuuttakaan. 4000 kg/ha hienofosfaattia riitti ainakin saman tuloksen saavuttamiseen kuin vuotuinen pelkkä superfosfaattilannoitus tässä happamassa hietamaassa, jossa maa-analyysien mukaan voitiin todeta hienofosfaatista liuenneen fosforin pidättyneen yksinomaan fluoridiin uuttuvaan fraktioon, siis verraten käyttökelpoiseen muotoon. Tosin suurin osa hienofosfaatin fosforista näytti vielä kokeen lopussa eli 9 vuoden kuluttua olevan melko muuttumattomana apatiittina happoon liukenevassa fraktiossa.

Ilmeisesti maissa, joissa hienofosfaatista hitaasti liukeneva fosfori pidättyy vaikeasti käytettävissä oleviksi raudan komplekseiksi, hienofosfaatin teho jää heikommaksi kuin tässä maassa.