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EFFECT OF APPLICATION OF INCREASING RATES OF MAGNESIUM SULPHATE ON THE FERTILIZING VALUE OF DIFFERENT CALCIUM PHOSPHATES

L. MADRID, C. MAZUELOS & P. de ARAMBARRI
Centro de Edafologia y Biologia Aplicada del Cuarto,
Seville, Spain

SUMMARY

From the following it can be seen that the addition of SM to the fertilizer increases ryegrass production on a light soil not well supplied with Mg. This increase in production appears to be due to the maintenance by SM of a high level of phosphorus in solution in the soil for the whole of the three month period that the experiment lasted. This effect on soil phosphorus also brings about a higher plant content of a range of nutrients, and also certain interactions between these nutrients. The quantity factor, Q, cannot be used on its own to predict the best yield levels. The treatments can be ranked, using a statistical procedure little employed in this type of work which also provides an estimate of the difference between an optimum production level and the actual production obtained from each treatment.

INTRODUCTION

In the presence of water calcium phosphates undergo a process of change giving rise, over the course of time, to other calcium phosphates of lower solubility, and to solutions more acid than was originally the case and containing more phosphate ions. These changes are influenced by soil properties, in that a proportion of the original phosphate ions is adsorbed from the soil solution onto the active surfaces of the soil. As a result, the concentrations of available phosphorus that plants encounter at specific stages of their development are influenced by the soil type on which they are growing and the type of phosphate fertilizer applied.

In a previous investigation [7] the effectiveness of four calcium phosphates was measured on ryegrass on a sandy hydromorphous soil from the valley of the Guadalquivir in south west Spain. To show that variation in magnesium ion concentration can affect the changes in certain calcium phosphates [1, 3, 10, 11, 12] the present work examined the effect of the addition of different amounts of magnesium to superphosphate and to other calcium phosphates. The soil used in this investigation is representative of a very large irrigated area along the Guadalquivir river.

THE EXPERIMENT

Fifty one pots were filled with 500 g of soil mixed with sand in the ratio 5 : 2. To each of forty eight of these pots three tablets were added containing in total 0.2 g of

P as one of the following four phosphates: concentrated superphosphate (TSP), monocalcium phosphate monohydrate (MCPM), dicalcium phosphate dihydrate (DCPD) and octocalcium phosphate (OCP). The tablets were placed in predetermined positions to allow their recovery at the end of the experiment. The forty eight pots were divided into groups of four. To each group one type of phosphate was added and some groups also received magnesium sulphate heptahydrate (SM) at two rates decided by the ratios between Mg added as sulphate and the calcium added in the phosphates. Three out of each group of four pots were sown with ryegrass, one sowing per pot, while the fourth was uncropped during the course of the experiment. The three remaining pots of the fifty one received no calcium phosphate and no magnesium but were sown with ryegrass as controls (TEST).

Each pot received, at the start of the experiment, 10 ml of a solution containing 0.45 g of $Ca(NO_3)_2$, 0.13 g of KNO_3, 0.11 g of $MnSO_4.H_2O$, 0.02 g of $ZnSO_4$, 0.008 g of $CuSO_4.5H_2O$, 0.04 g of H_3BO_3, 0.02 g of $Na_2MoO_4.2H_2O$ and 0.53 g of $FeC_6H_5O_7.5H_2O$. This application was repeated to each pot of ryegrass after each cut. The soil in the pots was maintained at field capacity with distilled water throughout the experiment.

The ryegrass was cut every two weeks, dried at 65°C, weighed and milled. Total P content was determined by phospho-vanado-molybdic photometry, total N by the Kjeldahl method, K by flame photometer and Fe, Ca and Mg by atomic absorption spectrophotometer. The analytical methods used are the reference methods of the Inter Institute Committee. In the same way, sub-fractions of the total P — organic P, acid-soluble P, lipid P and P in RNA and DNA — were determined [9].

At the end of the experiment the tablets in which the phosphate fertilizers were applied were recovered from the pots with and without SM. The tablets that initially contained OCP and DCPD, with or without SM, were easy to recover and appeared to be little altered. The tablets containing MCPM and MCPM + SM were difficult to recover, and those containing TSP and TSP + SM could not be located, so that a mixture of soil and fertilizer was taken for the post-experimental tests. The tablets or the mixture of them with soil were examined by X-ray diffraction.

Samples of soil were then taken from each pot, away from the zones of fertilizer placement, and analyzed as follows:

a) P soluble in 0.02*M* KCl — the intensity factor, I. Extraction period — four days. Soil: solution ratio — 1: 100;

b) isotopically exchangeable P — the quantity factor, Q. Equilibration time — 48 hours. Soil: solution ratio — 1: 100;

c) P in the soil solution. In some cases the I value obtained by method (*a*) was so small that it could not be determined accurately. In these circumstances the I value was found as follows: 2.5 g of soil was shaken for half an hour in 50 ml of solutions consisting of 1, 5 or 10 ml of Olsen solution and the remainder as 0.01*M* KCl. (The Olsen solution contained 0.5*M* $NaHCO_3$, so that the derived solutions were respectively 0.01, 0.05 and 0.1*M*). The quantity of P extracted by each of these solutions was then plotted against the $NaHCO_3$ concentration and the line obtained was extrapolated to zero $NaHCO_3$. This extrapolation gives the

quantity of P which would be extracted by a solution of KCl only. This value is assumed to represent the concentration of P in the soil solution, I.

All the determinations of P in solution in methods (*a*) to (*c*) described above were made by the method of Murphy & Riley [8].

The results for each pot of a treatment and for the individual cuts of ryegrass in each treatment were sufficiently close to allow the mean values to be used without real risk of error.

RESULTS AND DISCUSSION

Table 1 gives some properties of the soil used, table 2 the total yield of ryegrass from each treatment and the content of each plant nutrient, and table 3 the content of each of the total P fractions.

Table 1

pH H_2O	%					mg/100 g		
	Organic matter	$CaCO_3$	Sand	Silt	Clay	K_2O	Ca	Mg
7.7	1.5	10.3	30.1	22.7	47.2	6.3	442.0	23.0

Table 2

Treatment	Mg/Ca ratio in the fertilizer	% of the dry matter						Dry matter yield g
		N	10P	K	Ca	Mg	Fe	
TSP + SM	0.5	1.76	2.55	2.69	1.06	0.24	0.037	7.45
	0.1	1.92	2.40	2.79	1.19	0.25	0.034	8.39
TSP	—	1.90	1.87	2.65	1.16	0.22	0.039	8.19
MCPM + SM	0.5	1.96	2.27	2.81	1.17	0.27	0.036	7.98
	0.1	1.97	2.27	2.94	1.08	0.22	0.036	7.89
MCPM	—	1.89	2.35	2.70	1.07	0.21	0.041	8.03
DCPD + SM	0.5	2.16	1.75	2.91	1.14	0.25	0.033	7.63
	0.1	2.09	1.37	2.92	1.18	0.23	0.032	6.91
DCPD	—	2.14	1.20	2.85	1.06	0.18	0.038	6.97
OCP + SM	0.5	2.02	1.85	2.79	1.08	0.29	0.034	8.04
	0.1	2.14	1.27	2.94	1.13	0.22	0.034	7.93
OCP	—	2.09	1.17	2.71	1.19	0.21	0.040	6.67
TEST.	—	2.39	1.07	3.05	1.07	0.20	0.033	5.65

The results in table 2 indicate, for those treatments not receiving SM, a direct relationship between water solubility of the different fertilizers, the crop yields and the total P content of the plants. When SM was mixed with the fertilizer it was apparent that one of the SM treatments with TSP, the other with DCPD and both with OCP greatly increased the yield of ryegrass.

Table 3

Treatment	Mg/Ca ratio in the fertilizer	% of the dry matter				
		P Inorganic	P acid soluble	P lipid	P RNA	P DNA
TSP + SM	0.5	0.165	0.024	0.031	0.020	0.007
	0.1	0.142	0.013	0.019	0.003	0.002
TSP	—	0.089	0.008	0.006	0.018	0.002
MCPM + SM	0.5	0.146	0.009	0.024	0.005	0.001
	0.1	0.130	0.020	0.019	0.036	0.004
MCPM	—	0.087	0.031	0.007	0.020	0.006
DCPD + SM	0.5	0.095	0.014	0.020	0.037	0.004
	0.1	0.055	0.012	0.018	0.020	0.003
DCPD	—	0.051	0.005	0.010	0.020	0.004
OCP + SM	0.5	0.085	0.018	0.020	0.028	0.002
	0.1	0.067	0.012	0.015	0.007	0.005
OCP	—	0.041	0.003	0.007	0.013	0.001
TEST.	—	0.042	0.005	0.012	0.015	0.006

X-ray diffraction analysis of the soil, the fertilizer tablets and the fertilizer + SM tablets showed that TSP, with or without SM, was completely transformed into DCPD during the course of the experiment. The tablets initially containing MCPM were transformed into a mixture of DCPD and OCP (the latter recognizable by peaks at 18.76, 9.30, 9.02 Å etc.); the tablets of MCPM + SM were similarly transformed into DCPD and OCP, though there appeared to be less of the latter than was the case with MCPM without SM. Persistence of SM was not detected in any of the cases described above. In the tablets that initially contained DCPD some of this phosphate persisted, while OCP and hydroxyapatite (HA), with peaks at 3.44, 2.82, 2.78 and 2.72 Å, were formed. In the tablets of DCPD + SM both these materials persisted and in two only of this group the formation of OCP was definitely detected. In the DCPD + SM tablets peaks at 4.72 and 3.03 Å, characteristic of dimagnesium phosphate trihydrate (DMPT) were found, showing that this compound seems to form under these conditions. Finally, the OCP tablets appeared not to alter, while those of OCP + SM seemed to have deteriorated and to be less compact. It can be concluded that this change results from the formation of DMPT in these tablets.

The above results suggest two types of behaviour. The poor buffering capacity of the soil used results in all the added phosphates, except TSP whose acidity retards the changes, being transformed into OCP. This appears to be the naturally occurring phosphate in this soil, since ryegrass yield was very similar with OCP and with no added phosphate. In all the treatments without SM ryegrass yield is consistent with the form of phosphate detected by X-ray diffraction in the remains of the tablets.

The addition of SM affects the changes by facilitating the breakdown, possibly acidic, of OCP. DMPT is definitely formed but the X-ray diffraction results do not explain the greater yield of ryegrass with TSP and the low rate of SM, or with DCP

and the high rate, nor do they explain why neither rate of SM gave greater yields with MCPM.

The soil phosphate quantity factor, Q, is generally a good indicator of yield level in pot experiments. In this investigation there was a highly significant correlation ($r = 0.997$, $P < 0.001$) between the values for Q and yields from treatments not receiving SM. The correlation is lower and less significant ($r = 0.783$, $P < 0.1$) for the values for Q in the pots receiving SM and the yields obtained from them. It should be pointed out that the Q values are higher in the OCP + SM and DCPD + SM treatments than in those supplying OCP and DCPD only, and similar or only slightly higher in the TSP + SM and MCPM + SM treatments than with TSP and MCPM alone.

In pot experiments, soils with high I values normally give rapid growth [6]. In the present investigation there is a highly significant correlation ($r = 0.934$, $P < 0.001$) between the sum of the dry matter produced at the second and third cuts of ryegrass from the treatments with SM and the I values. It can be deduced from this that the addition of SM to the phosphates under investigation leads to a proportionally greater elevation in phosphate concentrations in the soil solution as the basicity of the phosphate present increases. X-ray examination of the residues of the tablets appears to show that this results from instability or from inhibition of OCP formation in the presence of SM.

In general terms, it is clear that the yields of ryegrass and the P content of the dry matter are directly correlated ($r = 0.702$, $P < 0.01$) and that the addition of increasing rates of SM to each fertilizer gives higher contents of inorganic P, acid-soluble P and lipid P (table 3). In addition, table 2 shows the negative correlation ($r = -0.658$, $P < 0.1$) between N and P contents in the ryegrass when the content of the former is halved as a result of better phosphate supply to the plant by the fertilizer treatments. No real relationship exists, however, between the amounts of each cation in the dry matter and the yield level, although the ryegrass grown with

Table 4

Treatment	Mg/Ca ratio in the fertilizer	N/10P	10P/K	N/K	10P/Fe	Ca/Mg	K/Mg	Ca/K
TSP + SM	0.5	0.69	0.95	0.65	68.90	4.42	11.20	0.39
	0.1	0.80	0.86	0.68	70.56	4.72	11.16	0.42
TSP	—	1.01	0.70	0.71	47.98	5.22	12.04	0.43
MCPM + SM	0.5	0.86	0.81	0.70	63.10	4.33	10.40	0.41
	0.1	0.86	0.77	0.67	63.10	4.90	13.36	0.36
MCPN	—	0.80	0.86	0.70	57.40	5.11	12.85	0.39
DCPD + SM	0.5	1.23	0.60	0.74	53.10	4.56	11.64	0.39
	0.1	1.52	0.46	0.71	42.85	5.13	12.69	0.40
DCPD	—	1.78	0.42	0.75	31.59	5.84	12.83	0.37
OCP + SM	0.5	1.09	0.66	0.72	54.40	3.72	9.62	0.38
	0.1	1.68	0.43	0.72	37.39	5.13	13.36	0.38
OCP	—	1.77	0.43	0.76	29.25	5.55	12.90	0.44
TEST,	—	2.19	0.35	0.78	32.43	5.25	15.25	0.35

fertilizers containing the high rate of SM had generally higher Mg contents than at the lower rate of SM or with none at all.

The contents of iron, magnesium and phosphorus in the ryegrass bear some relationship to each other; the ratio 10P/Fe is greater with the more soluble phosphate fertilizers and at the higher rate of added SM, as is shown in table 4 and as can be deduced from the results obtained by Bentley [2].

The cation ratios in table 4 show some variation, but less (except for Ca/Mg) than is the case for the anion ratios. The treatments with MCPM appear to need more K than Mg and more P than N, while the addition of SM does not affect these relationships.

The importance for crop production of interactions between plant nutrients has been investigated from various viewpoints and one of the conclusions is that the rate of crop growth depends on its content of organic anions [4, 13]. In this investigation it can be seen that the lack of equilibrium in the ionic charges that can be calculated from the results in table 2 can be considered to be proportional to the production of organic anions, ΔA, by the ryegrass. This parameter, ΔA, is directly correlated with crop yield and with its contents of P and of Mg (table 5).

Table 5

	Dry matter	Mg in the ryegrass	P in the ryegrass
ΔA	0.8961***	0.7820***	0.7645**

*** $P < 0.001$
** $P < 0.01$

In trying to relate all the results obtained to the level of yield of the TSP + SM (Mg/Ca ratio 1 : 10) treatment, which is assumed to be optimum, it is found that the interactions between nutrients and the large number of figures to be compared renders graphical representation ineffective. An alternative procedure has therefore been sought to provide an overall indicator of the relationship of each treatment to the optimum.

Normal statistical analysis does not provide a standardized method of analysing and expressing the individual variables. Harkins [5] has reported a method of non-parametric classification that is not inconvenient to use and that distributes the p parts of the subject of study, in this case the state of nutrition and the production of ryegrass for each treatment, in such a way that the actual differences between the parts are maintained and expressed on a p-dimensional basis, while it is also possible to define the differences clearly by means of a single number.

The method used involves the calculation of a standardized value for the distance between each observation and a suitably chosen control.

The control values must represent an optimum state, the standardized distances or calculated indices. The p parts are combined in such a way that the treatments having similar values for each variable have similar index values and that the very

different treatments have very different index values. In practice the procedure is as follows:

a) a maximum optimum value is chosen for each plant nutrient analysed in the ryegrass produced by each of the treatments tested. The vector of the optima is the sum of these values, from which the standardized distances are calculated. In the present case, the vector of the optima is obtained by assigning to each plant nutrient analysed in the ryegrass a value slightly higher than the maximum value actually found;

b) the recorded values for each plant nutrient are placed in order of magnitude, including the control. When two or more treatments give the same value for one of the plant nutrients, they are given the same ranking, this being the mean of the rankings which they would hold if they were different;

c) the variance of rank, V_i, is calculated for each plant nutrient from the formula:

$$V_i = \frac{1}{12n}[(n^3 - n) - \sum^{K}(f^3 - f)]$$

where n is the number of treatments excluding the control, f the number of replications of each value and K the number of separate values.
The value V_i is a measure of the distribution of the values of plant nutrient i among all the treatments represented diagrammatically in the form of an optimum nutrient equilibrium;

d) for each treatment a value S_n is calculated as the standard distance from its actual vector to the vector considered to be optimum.
In our investigation, the value S_n is substituted with advantage for the broken line representing a treatment in the optimum nutrient equilibrium diagram:

$$S_n = \sum^{P}\frac{(r_i - r_n)^2}{V_i}$$

where P is the number of plant nutrients analysed, r_i the ranking order of the value for the plant nutrient i of treatment n and r_c the ranking order of the optimum for the control.

The values of S_n show that the more soluble phosphates used, TSP and MCPM, respond best to low rates of SM while the less soluble phosphates give the best results and are more effective when mixed with high rates of SM.

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STUDIES ON RESPONSE OF WHEAT TO PHOSPHATE FERTILIZATION

S. N. SHARMA, K. S. PANTA, L. A. DIXIT,
Rajendra PRASAD & Rajat DE
(Indian Agricultural Research Institute, New Delhi, India)

SUMMARY

The data from two experiments conducted during 1969-70 to 1974-75 at Indian Agricultural Research Institute, New Delhi, show that dwarf wheats respond well to P application and that P fertilization is higly profitable on low available P soils. In one of the experiments the first increment of 30 kg/ha P_2O_5 gave additional 12 q/ha grain and a profit of Rs. 12.00 per rupee invested in phosphate.

INTRODUCTION

Prior to 1965 only tall wheats were grown in India and, in general, a response of 1 to 2.2 q/ha grain was obtained to an application of 22.4 kg ha/P_2O_5 (Panse *et al.* 1947; ICAR, 1959; Abraham *et al.*, 1963; Raheja *et al.*, 1965). Thus, even at this low level of P fertilization only about 4.5 to 10 kg additional grain per kg P_2O_5 was produced. In some experiments (Raheja *et al.*, 1965) where higher rates, namely 44.8 and 67.2 kg/ha P_2O_5 were studied, the additional responses were of a still lower order.

With the introduction of high yielding dwarf wheats from Mexico in the mid-sixties the P fertilization practices for wheat changed rapidly as these wheats were found to be appreciably responsive to P. In field experiments conducted under All India Coordinated Wheat Improvement Project of the Indian Council of Agricultural Research (1969) a significant response to P was obtained at most of the research centres and it ranged from 5 to 10 q/ha when P was applied at 40 kg/ha P_2O_5. This worked out to 12.5 to 25 kg additional grain per kg P_2O_5. The experiments conducted under All India Coordinated Agronomic Experiments Scheme of the Indian Council of Agricultural Research at 24 centres located in ten major soil groups of India during the years 1967-68 and 1968-69 showed that the response of wheat to P was high in soils with low available P belonging to black, mixed red and black and alluvial soil groups (Mahapatra & Leela Vahti, 1971). Field experiments were, therefore, conducted during crop years 1969-70 to 1974-75 at Indian Agricultural Research Institute, New Delhi, to study the response of wheat to P.

EXPERIMENTAL

Experiment 1: It was conducted during 1969-70 and 1970-71 on a soil of pH 7.7 (1 : 2.5 soil to water ratio) having 0.52 % organic C and 0.0403 % total N. The available P (0.5 *M* $NaHCO_3$ extractable) was 5 and 10 kg/ha in 1969-70 and 1970-71, respectively. Treatments consisted of all combinations of 4 levels of P (0, 20, 40 and 80 kg/ha P_2O_5), 3 levels of N (60, 120 and 180 kg/ha) and two methods of application (all applied to soil and 3/4 applied to soil + 1/4 applied through foliage). The experiment was laid out in a confounded balanced 4 × 3 × 2 design in 12 plot blocks with 3 replications. A no fertilizer control was provided in each block. The partially confounded effects were the components of the interaction P × M and P × N × M.

Experiment 2: It was conducted during 1971-72 to 1974-75 on a sandy clay loam soil of pH 8.2 (1 : 2.5 soil to water ratio) having 0.55 % organic C, 0.0437 % total N and 4.5 kg/ha available P (0.5 *M* $NaHCO_3$ extractable). The experiment was laid out in a randomised block design with four replications. The rates of P studied were 0, 30, 60 and 90 kg/ha P_2O_5, applied as concentrated superphosphate. The wheat variety used was Kalyan Sona (a double dwarf genotype) in 1971-72, 1973-74, and 1974-75, while in 1972-73 the variety used was Sonalika (a single dwarf genotype). All plots received 120 kg/ha N and 40 kg/ha K_2O in all the four years. In addition zinc sulphate at 25 kg/ha was added in 1971-72 and 1973-74. Observations were recorded on height of plant, number of ear bearing shoots per metre row length, length of ear, grain per ear and thousand grain weight during the first two years, while the grain and straw yields were recorded in all the four years.

RESULTS AND DISCUSSION

The data on growth and yield contributing characters are given in table 1, while the data on grain and straw yield are presented in table 2 and fig. 1.

Growth and yield attributing characters

Experiment 1: The number of ear bearing shoots increased as the rate of P was increased up to 80 kg/ha P_2O_5, However, the difference between 40 and 80 kg/ha P_2O_5 was significant only in 1970-71 (table 1). The length of the ear was significantly increased up to 80 kg/ha P_2O_5 in 1969-70 but only due to first increment of P (20 kg/ha P_2O_5) in 1970-71. Number of grain per ear was significantly increased up to 80 kg/ha P_2O_5 in 1969-70, there being no significant difference between the levels in 1970-71.

The 1000-grain weight increased in most of the years with P application except in 1969-70.

Experiment 2: The height of the plants, ear bearing shoots per metre row length and 1000-grain weight in wheat significantly increased due to the first increment of

Table 1

Effect of rates of phosphate on growth and yield contributing characters of wheat.

Rates of phosphate (kg/ha P_2O_5)	Height of plant (cm)		Ear bearing shoots/meter row length		Length of ear (cm)		Number of grain/ear		1000-grain weight (g)	
	Experiment 1									
			1969-70	1970-71	1969-70	1970-71	1969-70	1970-71	1969-70	1970-71
0			66	69	9.2	9.1	47	45	31.6	32.7
20			80	81	9.4	9.6	50	46	30.3	33.5
40			87	87	9.5	9.7	51	46	29.3	33.9
80			90	92	9.7	9.7	53	43	28.8	33.4
LSD (P = 0.05)			4.4	4.6	0.2	0,3	1.7	NS	0.7	0.8
	Experiment 2									
	1971-72	1972-73*	1971-72	1972-73	1971-72	1972-73	1971-72	1972-73	1971-72	1972-73
0	84.4	64.6	160	104	9.3	8.7	41	28	30.3	44.9
30	91.3	78.3	179	142	9.3	9.6	44	32	31.4	47.7
60	94.2	81.0	198	160	10.3	10.1	51	34	31.8	48.0
90	95.4	82.3	188	176	10.2	10.2	48	34	31.6	47.9
LSD (P = 0.05)	4.7	4.6	24	19	0.7	0.5	6.0	2.7	1.0	1.5

* Wheat variety grown was Sonalika. In all other years it was Kalyan Sona.

Table 2

Grain and straw yield of wheat as influenced by rates of phosphate.

Rates of phosphate (Kg/ha P_2O_5)	Grain (q/ha)					Straw (q/ha)				
	Experiment 1									
	1969-70		1970-71		Mean	1969-70		1970-71		Mean
0	41.0		38.4		39.7	57.0		58.8		57.9
20	46.0		46.1		46.1	65.3		71.3		68.3
40	49.5		47.9		48.7	74.4		71.3		72.9
80	53.6		48.0		50.8	78.6		73.4		76.0
LSD (P = 0.05)	2.4		2.6			4.0		3.2		
	Experiment 2									
	1971-72	1972-73	1973-74	1974-75	Mean	1971-72	1972-73	1973-74	1974-75	Mean
0	43.8	21.9	16.5	21.7	26.0	69.4	37.8	34.0	48.9	47.5
30	49.0	38.9	28.4	37.4	38.4	79.3	64.3	55.0	72.2	67.7
60	51.5	43.5	35.6	39.1	42.4	85.2	71.4	68.1	74.3	74.7
90	57.4	50.4	38.8	43.2	47.5	89.9	79.9	71.5	82.4	80.9
LSD (P = 0.05)	6.4	4.7	3.4	4.7		12.0	7.3	6.4	12.7	

* Wheat variety grown was Sonalika. In all other years it was Kalyan Sona.

30 kg/ha P_2O_5; there being no significant additional increase due to higher rates of P application.

The number of grain per ear was also significantly increased by P application. In the case of Kalyan Sona, the increase due to 30 kg/ha P_2O_5 over no P as well as the increase due to 60 kg/ha P_2O_5 over 30 kg/ha P_2O_5 was significant. However, in the case of Sonalika only the first increment of 30 kg/ha P_2O_5 gave a significant increase in the number of grain per ear. Sharma (1971) and Bhendia (1972) have also reported significant beneficial effects of phosphate application on growth and yield attributing characters in wheat.

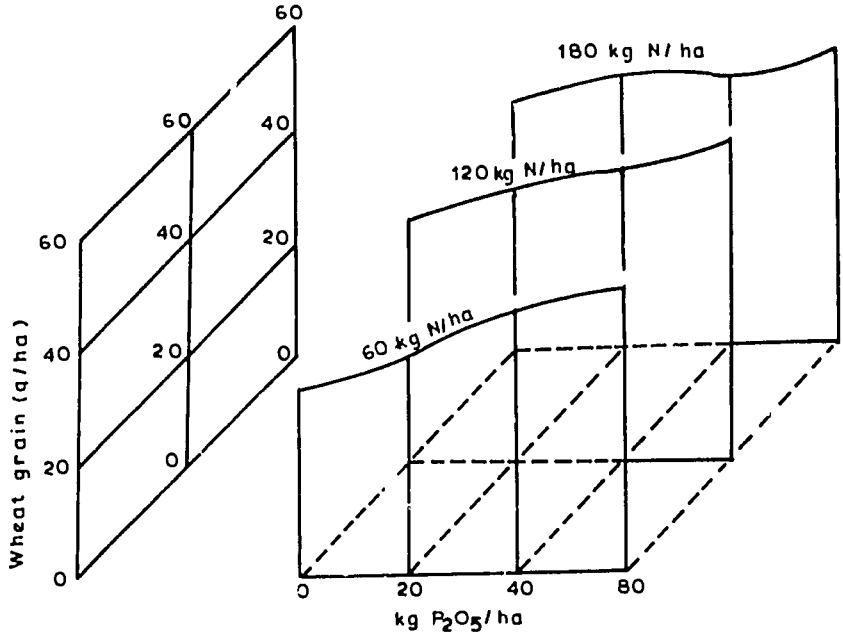

Fig. 1. Grain yield of wheat as affected by N and P fertilizers.

GRAIN YIELD

Experiment 1: A significant response to P was obtained up to 80 kg/ha P_2O_5 in 1969-70 but in 1970-71 it was restricted only to 20 kg/ha P_2O_5 (table 2). This could be due to higher P status of the soil of the experimental field in 1970-71. Also in 1970-71 the grain yield at 40 and 80 kg/ha P_2O_5 remained lower than in 1969-70. The data in table 1 indicate that the lower number of grain per ear in 1970-71 than in 1969-70 was the principal reason for lower yields.

In 1969-70 the interaction N × P was significant and showed that the highest grain yield of wheat was obtained with 120 kg/ha N and 80 kg/ha P_2O_5 (fig. 1). Application of N beyond 120 kg/ha lowered the grain yield of wheat as well as response to phosphate.

Experiment 2: P application increased the grain yield of wheat in all the four years of study; the response being observed up to 90 kg/ha P_2O_5 (table 2). The

response equation based on the yield data pooled over the 4 years was:

$$Y = 25.47 + 0.4108 X - 0.002 X^2$$

The first increment of 30 kg/ha P_2O_5 gave an increase of about 12 q/ha over the plots receiving no P but 120 kg/ha N and 40 kg/ha K_2O. These results show that large production increases are possible with P fertilization on P deficient soils. The next two increments of 30 kg/ha P_2O_5 (60 and 90 kg/ha P_2O_5 rates) gave an additional increase in wheat grain yield of about 4 q/ha each.

STRAW YIELD

Experiment 1: The straw yield was significantly increased due to P application in both years: the response to P was obtained up to 80 kg/ha P_2O_5 in 1969-79 but only up to 20 kg/ha P_2O_5 in 1970-71. Thus the trend was the same as that observed in the case of grain yield.

Experiment 2: P application increased the straw yield in all the four years; the difference between 0 and 30 kg/ha P_2O_5 being significant in all the four years, while 90 kg/ha P_2O_5 gave significantly more straw than 30 kg/ha in 1972-73 and 1973-74. The major increase in straw yield was again with the first increment of 30 kg/ha P_2O_5 in all the years studied and was about 20 q/ha.

ECONOMICS OF PHOSPHATE FERTILIZATION

As the experiment 2 was conducted for 4 years and also because the response to P was constant the economics of phosphate fertilization was calculated from this experiment only and the information is presented in table 3. The data show that a return of Rs. 12.00 was obtained on each rupee invested in P fertilizers when the first increment of 30 kg/ha P_2O_5 was applied. The subsequent two increments of 30 kg/ha P_2O_5 (60 and 90 kg/ha P_2O_5 rates) gave a return of Rs. 7.95 and 6.94 respectively.

Table 3

Economics of phosphate fertilization of wheat.

Fertilizer applied (kg/ha)			Response to P (q/ha)	kg grain per kg P_2O_5	* Return per rupee invested in P_2O_5
N	K_2O	P_2O_5			
120	40	0	0	0	0
120	40	30	12.4	41.3	12.00
120	40	60	16.4	27.3	7.95
120	40	90	21.5	23.9	6.94

* Cost of P_2O_5 Rs. 3.61/kg; Price of wheat Rs. 105/q.

Thus the results presented in this paper clearly show that on P deficient soils, P fertilization can largely increase wheat production and profit to farmers. As Ramamoorthy & Bajaj (1969) have reported that most Indian soils are low to medium in available P, P fertilization can be a significant input in increasing the wheat production in India.

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BIBLIOGRAPHICAL ABSTRACTS *

SOIL AND PLANT ANALYSIS

BARROW, N. J. & SHAW, T. C. — **Sodium bicarbonate as an extractant for soil P. II. Effect of varying the conditions of extraction on the amount of P initially displaced and on the secondary adsorption.** *Geoderma,* 1976, 16, 109-23 (En) (*Soils & Fert.*, 1977, 40, 2, No. 428).

The effects of varying the period of shaking, the concentration of bicarbonate, the pH, and the dryness of the soil on the P extracted by sodium bicarbonate were investigated. A regression procedure in which the soil solution ratio was the independent variable was used to separate the effects on the amount of P initially displaced from those on the secondary adsorption increased with period of extraction. At small soil: solution ratios the effect on displacement was dominant and the net effect was a continuing increase in the amount of P in the extract. At large soil:solution ratios, secondary adsorption eventually predominated and caused a decrease in the amount of P in the extract. Increasing the bicarbonate concentration from 0.1 to 1.0 *M* decreased secondary adsorption but had no significant effect on the initial displacement. The effects of changing the concentration were most marked at low concentrations. Increasing the pH of 0.5 *M* bicarbonate solutions increased the amount of P initially displaced but had no significant effect on secondary adsorption. In the absence of bicarbonate, the effects of pH differed: increasing the pH decreased secondary adsorption. Secondary adsorption was important when the ratio of soil to solution was large and in these cases the net effect of pH on bicarbonate was greatest near the pK_2 of carbonic acid. Drying the soil increased the amount of P displaced from the soil after 30 min extraction but the effect was eliminated by extending the period of extraction to 16 h. 3748

BARROW, N. J. & SHAW, T, C. — **Sodium bicarbonate as an extractant for soil P. III. Effects of the buffering capacity of a soil for P.** *Geoderma,* 1976, 16, 273-83 (En) (*Soils & Fert.*, 1977, 40, 4, No. 1675).

An index of the buffering capacity for P of a group of soils was obtained by measuring adsorption of P from dilute solutions of $CaCl_2$. The effect of buffering capacity on the amount of P initially displaced by solutions of sodium bicarbonate and on the amount of secondary adsorption from bicarbonate was then studied. These two effects were separated using a regression procedure in which the soil:solution ratio was the independent variable. As buffering capacity increased the amount of P initially displaced decreased and the amount of secondary adsorption increased. Both these changes resulted in a decrease in the amount of P in the extract. The effect of buffering capacity was greater with the Olsen method (soil:solution ratio 1:20; 30 min) than with the Colwell method (soil:solution ratio 1:100; 16 h). The effect of buffering capacity on the proportion of added P initially displaced from the soil became more marked as the period of incubation prior to extraction was increased. Bicarbonate soil tests would therefore indicate that, on soils of low buffering capacity, the

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* (R) following some abstracts means « Author's summary ».
The following abbreviations have been used in the abstracts:

MCP	Monocalcium phosphate	TSP	Triple superphosphate
DCP	Dicalcium phosphate	RP	Rock phosphate
TCP	Tricalcium phosphate	AN	Ammonium nitrate
AP	Ammonium phosphate	AS	Ammonium sulphate
DAP	Diammonium phosphae	NTP	Nitrophosphate
MAP	Monoammonium phosphate	DM	Dry matter
SP	Superphosphate (in general)	ws	Water-soluble
SSP	Single superphosphate	OM	Organic matter
CSP	Concentrated superphosphate	d	Day(s)

The two-letter groups following the reference of the abstract indicate for the first group (with a capital letter) the original language of the paper, and afterwards (with small letters), the language of the possibly existong « Author's summary ».

Afrikaander	Af	German	De	Polish	Pl
Arabic	Ar	Greek	Gr	Portuguese	Pt
Bulgarian	Bg	Hebrew	He	Rumanian	Ro
Chinese	Ch	Hungarian	Hu	Russian	Ru
Czech	Cs	Indonesian	In	Serbo-Croat	Cr
Danish	Da	Italian	It	Slovak	Sk
Dutch	Nl	Japanese	Ja	Spanish	Es
English	En	Korean	Ko	Swedish	Sv
Finnish	Fi	Malay	My	Turkish	Tr
French	Fr	Norwegian	No		

decrease with time in availability of applied P would be smaller than on soils of high buffering capacity. This effect differs from that observed with plants. 3749

DALAL, R. C. & HALLSWORTH, E. G. — **Measurement of isotopic exchangeable soil P and interrelationship among parameters of quantity, intensity, and capacity factors.** *Soil Sci. Soc. Amer. J.*, 1977, 41, 81-6 (En).

The *E*-values obtained in the laboratory by carrier-free (*E*-value) and carrier-methods (*Ec* value) were comparable to *L*-values obtained in the greenhouse in low-P fixing soil but were very much higher in high-P fixing soils. In the latter group *E*-values obtained by inverse-dilution technique (*E*LD value) were more comparable to *L*-values. The parameters for available P in terms of quantity, intensity and capacity factors were discussed in relation to soil properties. The *E*, *Ec*, and Q_o values were influenced primarily by total P content of soils whereas *L* value was significantly correlated with exchangeable Ca and Mg, pH, organic C and oxalate, and dithionite extractable Fe (Fe_o and Fe_d) of soils. *E*LD value was correlated with oxalate extractable Al and organic C of soils. Thus both *L* and *E*LD values were affected by soil characteristics that influence the availability of P in soil. The intensity factor was mainly influenced by soil reaction. The parameters of capacity factor, both P buffering capacity (PBC) and maximum buffering capacity (Mb) were significantly correlated with dithionite extractable Al (Al_d) of soils. (R) 3741

DICK, W. A. & TABATABAI, M. A. — **Determination of orthophosphate in aqueous solutions containing labile organic and inorganic P compounds.** *J. Environ. Qual.*, 1977, 6, 82-5 (En).

A simple and precise colorimetric method of determining orthophosphate in aqueous solutions containing labile organic and inorganic P compounds is described. It involves a rapid formation of molybdenum blue color by the reaction of orthophosphate with molybdate ions in the presence of ascorbic acid-trichloroacetic acid and citrate-arsenite reagents and complexation of the excess molybdate ions to prevent further formation of blue color from the phosphate derived from hydrolysis of the acid-labile P compounds. The color is stable up to 24 h. The method is sensitive and accurate, and it permits determination of μg quantities of orthophosphate in samples containing large amounts of acid-labile P compounds. (R) 3714

ENWEZOR, W. O. — **Soil testing for P in some Nigerian soils: 1. Comparison of methods of determining available P in soils of South Eastern Nigeria.** *Soil Sci.*, 1977, 123, 48-53 (En).

Seven chemical extractants for determining available soil P have been compared. Strong alkali extraction using 0.1 *N* NaOH extracted the most P but was the least precise in predicting yields ($r = 0.58$). Inclusion of organic P in the extract reduced the precision further ($r = 0.56$). Extraction with dilute acids and an anion exchange resin gave lowest values for available P but resin extraction was superior to dilute acid extraction in predicting percentage yields, with a correlation coefficient of 0.72 for resin extraction compared with 0.60 and 0.68, resp., for 0.002 *N* H_2SO_4 and 3 % acetic acid. Extraction with 0.5 *M* $NaHCO_3$ and 0.03 *N* NH_4F plus 0.025 *N* HCl were equally precise in predicting percentage yields with correlation coefficients of 0.67 and 0.68, resp. P extracted with 0.03 *N* NH_4F plus 0.1 *N* HCl gave the highest correlation with percentage yield ($r = 0.74$). This method, being additionally simple, quick and effective in extracting P, has been recommended for the routine soil testing for P in the acid soils of southeastern Nigeria. (R) 3695

ENWEZOR, W. O. — **Soil testing for P in some Nigerian soils: 2. Predicting responses to P application for soils of South Eastern Nigeria.** *Soil Sci.*, 1977, 123, 111-6. (En).

Responses to P by potted maize were determined in the greenhouse on soil samples taken from 68 locations in southeastern Nigeria and correlated with available P extracted by a selected chemical method.

Responses to P application were shown to be widespread. DM yields were especially low in the acid sandy ferrallitic soils derived from sandstones and coastal plain sands, when no P was applied. An application of over 28 kg/ha P was needed in many cases to elicit a response. Soils from the lowland rain forest areas and soils derived from basement complex rocks gave higher DM yields and fewer responses to P application than soils from the savanna areas and those derived from sedimentary rocks. Available P correlated positively with the percentage yield of maize and the correlation coefficient, $r = 0.648$, was significant at the 0.1 % level. Significant responses to P application occurred when the percentage yield was below 55 % and when available P content of the soil was less than 33.6 kg/ha. (R) 3696

EZHOW, R. I. & POLYAKOV, A. N. — **Methods of agrochemical soil survey in the USSR.** *8th Int. Fert. Congress, Moscow*, 1976, 1, 147-53 (Ru).

On the basis of the investigations it was established that the size of elemental site in the black earth zone may be 25-40 ha. Practical check-up conducted on different subtypes of black soils showed that the selection of mixed sample consisting of 50 individual samplings from 25 ha provided for the error in the active nutrient content equal to 1.4-10.8 %. These errors are within the limits of accuracy acceptable for qualitative soil analyses. 3572

GLADKOVA, K. F. — **Usage of ^{32}P for determination of available and soluble reserve P in USSR soils.** *8th Int. Fert. Congress, Moscow*, 1976, 2, 189-94. (Ru)

The supply of P available to the plants has been measured in soils from plots of 53 perennial field

experiments. The total content of available and dissolved P in soil has been established with ^{32}P. Oats and spring wheat were used as experimental plants. The results showed that 22.6 % fertilizer P had been accumulated in soils in available forms. The correlation and regression coefficients for the relationships between the pool of available P ant the pool of labile P of soils have been calculated. The data indicate a high degree of agreement with the solubility of soil P (r = 0.70-0.95). 3592

HONG, C. K. & YAMANE, I. — **The identification of soil inositol phosphates and inositol by use of thin-layer chromatography.** *J. Sci. Soil Manure Japan,* 1976, 47, 4, 122-6 (Ja) (*Soil Sci. & Plant Nutr.*, 1976, 22, 3, 351-2).

The following results were obtained in this investigation:

1) Development with acetone: 30 % acetic acid = 4 : 6 moved inositol mono-hexaphosphates together into a compact spot separated sufficiently from other phosphate esters and inorganic phosphate.

2) Development with methanol: aqueous ammonia: acetic acid: dist'd H_2O=50 : 15 : 5 : 30 resolved inositol mono-hexaphosphates into six spots.

3) Development with acetone: dist'd H_2O=7 : 3 resolved inositol isomers into individual spots which were separated from other cyclitol, hexoses and pentoses sufficiently.

4) Some individual spots of inositol phosphates and inositols were obtained on chromatograms of humic acid and fulvic acid fractions extracted from a volcanic ash soil by three extracting methods. 3672

HONG, C. K. & YAMANE, I. — **The identification and estimation of inositol phosphates (IP) in humid acid fraction.** *J. Sci. Soil Manure Japan,* 1976, 47, 5, 153-9 (Ja) (*Soil Sci. & Plant Nutr.*, 1976, 22, 3, 354).

The results of various investigations relating to the above question were as follows:

1) Much high values of IP could be obtained with a new procedure having higher intensity of alkaline hydrolysis and NaOBr oxidation treatments than the present ones. However, mineralization of IP increased as the intensity of the treatments increased, which resulted in the lower values of IP. And the maximum value of IP determined was 69.50 % of total organic P in the HA fraction.

2) From the results that mineralization rate of some metal IP_6 salts prepared increased as violency in the hydrolysis and oxidation increased, the increase of inorganic P which took place in the quantitative procedures could not be explained. And some metal IP_6 salts prepared were recovered as Ba-IP_6 salts quantitatively,

3) Almost all of Na-IP_6 salt, inositol and inorganic P added in the soil were recovered through the treatments of organic P extraction and IP estimation procedures. And they were all determined only in the FA fraction, and not in the HA fraction. This means that there occurred no incorporation of IP in free state into the HA fraction, and no synthesis of IP from free inositol and inorganic P during the procedures.

4) TLC of IP in the HA and FA fractions indicated almost all of IP consisted of IP_6. And it was estimated that the origin of IP was in plants, and not in animals nor in microorganisms.

5) From the experimental results of organic P, inositol, and IP in the HA and FA fractions, and from the differences in the difficulty of IP determination, differences in the chemical nature of IP in soil were discussed. 3673

HONG, C. K. & YAMANE, I. — **Gel identification of the humid and fulvic acid fractions and inositol phosphates.** *J. Sci. Soil Manure Japan,* 1976, 47, 6, 263-9 (Ja) (*Soil Sci. & Plant Nutr.*, 1976, 22, 3, 359-60).

In order to clarify the characteristics of IP in both the fractions extracted by the method using resin and acetyl acetone, experiments by the use of gel filtration technique were carried out. The resuls are as follows:

1) IP, inositol, organic P, and humus in the humic acid fraction were distributed together in both the Sephadex G-200 and G-25 filtrations. The two molecule-size fractions of IP were obtained, namely: > 200,000 and 200,000 to 5,000. The higher molecule-size fraction and the lower molecule-size fraction had 23 and 70 % IP in the humic acid fraction, respectively.

2) Sephadex G-25 and G-15 were used for the fractionations of IP in the fulvic acid fraction. IP, inositol, organic P and humus were distributed together in both the filtrations. The two molecule-size fractions of IP were obtained, namely: about 5,000 and 5,000 to 1,500. The higher molecule-size fraction and the lower molecule-size fraction had 10 and 80 % IP in the fulvic acid fraction, respectively.

3) In the lower molecule-size fraction of the fulvic acid fraction, differing from the other three fractions of P which consisted of IP, only 60 % of organic P were in IP form. It means that the remaining 40 % were other organic compounds. And almost all the inorganic P in the fulvic acid fraction were contained in the fraction. Therefore, in order to make clear the distributions of inorganic P and IP, further fractionation was performed according to the Forsyth's method using charcoal, with the result that inorganic P could be separated clearly from IP. The former existed in the A fraction and the latter in the D fraction, in which almost all the humic substances of the fulvic acid fraction were contained.

4) The results of gel and charcoal fractionations could lead the clear understanding that almost all IP were in a form bound with humus, "IP-Humus complexes". The roles of amino acids and Al as the agents of the bound formation were estimated.

5) The relations between the molecule-size distributions of IP and the quantitative values were discussed. 3674

IVANOV, P. — **The determination of the P requirement of a chernozem and of grey forest soils**

by lactate methods. *Pochvoz. Agrokh.*, 1976, 11, 68-76 (Bg, en, ru) (*Soils & Fert.*, 1977, 40, 3, No. 1007).

The ratios between the amounts of P extracted from 40 soils by the Egnér, Egnér-Rhiem, AL and KAL methods averaged 1.0 to 1.23 to 1.69 to 1.1 resp.. Differences between the amounts extracted were much greater for carbonate soils, for which the first two methods gave low results. The results obtained by all the methods agreed well with P uptake by wheat and ryegrass to which MCP or DCP was applied in a pot experiment, but the KAL method gave the best agreement. When hyperphosphate was supplied to the plants, only the KAL method gave results agreeing with P uptake, all the other methods giving high results. 3775

LE BUANEC, B. & DIDIER DE SAINT-AMAND, R. —**Presence of a deficiency of P on granitic soils in Ivory Coast and the elaboration of a method for its diagnosis.** *Ann. Univ. Abidjan Sci.*, 1975, 11, 103-22 (Fr) (*Abst. Trop. Agric.*, 1977, 3, 4, No. 13843).

Field trials and laboratory tests in Ivory Coast have shown that the granitic soils, embracing 60 % of the territory, are generally deficient in P. 3811

MITRA, R. P. & SINDHU, P. S. — **Uptake of P by some layered silicate minerals in relation to their titration curves with acid and base.** *J. Indian Soc. Soil Sci.*, 1976, 24, 29-47 (En).

Uptake of P by some layer silicate minerals, *viz.*, pyrophyllite, kaolinite (both in natural forms), montmorillonite and mica (both as Na-systems) has been studied in relation to their titration curves with NaOH, HCl, H_3PO_4 and Na_3PO_4. (R) 3813

OWENS, L. B. *et al.* — **Determination of inorganic P in oxalate extracts of soils.** *Soil Sci. Soc. Amer. J.*, 1977, 41, 148-9 (En).

A simple and rapid procedure for the determination of inorganic P in acid ammonium oxalate extracts of soils was developed by modifying the ascorbic acid-molybdenum blue colorimetric method. The oxalate interference in the determination of P was overcome by addition of excess ammonium molybdate. A molar ratio of molybdate to oxalate, in the final solution, of 2.51 : 1 was required in order to eliminate the oxalate interference. (R) 3742

SUMMER, M. E. — **Preliminary N, P, and K foliar diagnostic norms for soybeans.** *Agron. J.*, 1977, 69, 226-30 (En).

Preliminary DRIS Beaufils' Diagnosis and Recommendation Integrated System norms for soybean leaves are developed from 1,245 sets of data on elemental (NPK) leaf composition and corresponding yields. This is done by dividing the population of observations into two subpopulations on the basis of yield. The norms are calculated from those forms of expressing the leaf parameters which significantly discriminate between the two subpopulations. The degree of nutrient imbalance in the plant is expressed in terms of a DRIS index which measures the extent to which a particular nutrient deviates from the established norm. The norms are developed in such a way that the influence of age of tissue sampled on the diagnostic index is minimized. The DRIS norms enable one to diagnose whether N, P or K is the nutrient most limiting to soybean production in a particular case to be diagnosed. The results show that the diagnosis can be made irrespective of variety and age at which the leaf is sampled. (R) 3752

TRUONG BINH & PICHOT, J. — **Influence of P in the test plant seeds on the determination of isotopically exchangeable P (L value).** *Agron. Trop.*, 1976, 31, 379-86 (Fr, en, es).

The determination of L values in the soils poor in P is difficult especially because of the P in the plant test seeds. As the various solutions proposed to meet these difficulties were not very satisfactory, the authors compared to ryegrass, which is usually used, a plant having very small seeds: common bent. The study carried out on sand and a soil with a high P fixation capacity showed various possible causes for the overestimated L value and made it possible to present a satisfactory experiment procedure. (R) 3799

II

DYNAMICS OF NUTRIENTS IN THE SOIL

a. PHYSICAL AND CHEMICAL FACTORS

ADEPETU, J. A. & COREY, R. B. — **Changes in N and P availability and P fractions in Iwo soil from Nigeria under intensive cultivation.** *Plant & Soil*, 1977, 46, 309-16 (En).

Two N-P factorial experiments, one on a site previously in bush fallow and the other previously in arable crops, were used to follow changes in the P status of Iwo soils under continuous cultivation. Marked yield response of maize to N was found at both sites, with the response being relatively small in the early crop at the fallowed site. Yield response to P was found only at the cropped site and then only if N was applied. About 25 % of the organic P in the surface soil was mineralized during the two cropping periods of the rainy season which resulted in release of about 3 times as much P as was taken up by the maize. Most of the mineralized P as well as any added P was converted to Fe-and Al-P. Apparently the rate of organic P mineralization in this soil is rapid enough for a few years following clearing to maintain adequate P activity for plant growth whereas N deficiency shows up very early. (R) 3784

AHMAD, N. & MALIK, D. M. — **Changes in pH and availability of native soil P under submerged conditions.** *J. Agric. Res.*, 1975, 13, 397-404 (En).

That effect was studied in a pot experiment using five different soil series of the Punjab. Time of submergence significantly decreased the pH at 4th week and then it remained almost at a constant level. The availability of native soil P significantly increased with submergence in all the soil series of Punjab. The maximum increase was however noted in the 7th week of submergence. (R) 3812

ANDRIESSE, J. P. *et al.* — **On the variability of amorphous materials in andosols and their relationships to irreversible drying and P-retention.** *Geoderma*, 1976, 16, 125-38 (En) (*Abst. Trop. Agric.*, 1977, 3, 1, No. 12221).

Amorphous components of soils from Costa Rica, Japan, New Zealand and Rwanda are analysed by chemical, physical and mineralogical means. A comparison shows that P retention exhibits no significant relationship with composition of the amorphous components with possibly lowest P-retention in highly siliceous members. Irreversible drying is strongly related to either discrete phases of Si and Al gels, thus to the nature of amorphous component, rather than to quantity. (R) 3805

BARRETO, W. DE O. & CASTRO, A. F. DE. —**Movement of P in the soils which occur in the area of the Federal Rural University of Rio de Janeiro.** *Agronomia*, 1969, 27, 35-50 (Pt) (*Abst. Trop. Agric.*, 1977, 3, 1, No. 12203).

The movement of P (applied at 3 levels as monobasic Ca phosphate) from the top layer of soils downwards under the influence of a simulated rainfall was studied in pot tests. It was found that (1) in the soils of the Itaguaí, Seropédica and Guandu series, all high in clay and sesquioxides content, there was no penetration of P beyond the top 5 cm of the soil, due to P fixation; (2) in the soils of the Piranema (organic) and Ecologia series (very sandy) the movement of P downwards became noticeable only after the application of the equivalent of a 3-months rainfall; and (3) the rate of P-fixation was the same at the 3 levels of applied P-fertilizer. 3803

DEB, D. L. & ZELIANG, C. R. — **Zn-P relationship in alluvial soil as measured by crop response and soil and plant analyses.** *Indian J. Agric. Sci.*, 1976, 46, 74-8 (En).

Greenhouse experiments were conducted on an alluvial soil on rice and wheat to study the Zn-P relationship as measured by crop response and soil and plant analyses. Growth response to P application was significant in rice and wheat, but response to Zn application was significant only in wheat at 20 kg Zn/ha level. Application of P increased the P content of both the crops, but decreased the Zn content of wheat plants up to 100 kg/ha P level, increased the available P in the soil and decreased the available Zn in the soil after rice. Zn application increased the Zn content of wheat plants, but decreased the Zn content of rice plants. Zn application decreased the P content of wheat plants, but in rice plants the P content showed a significant increase at the level of 10 kg/ha Zn. Application of Zn increased the available Zn in soil after wheat, but did not affect the available P under both the soil management conditions. (R) [3508

DERZHAVIN, L. M *et al.* — **Regional peculiarity of arable soils in respect of nutrient element content and fertilizer efficiency in the USSR.** *8th Int. Fert. Congress, Moscow*, 1976, 1, 140-7 (Ru).

The heterogeneity of distribution of soil areas with different mobile P, exchangeable K and acid content according to soil zones, union republics, economical regions and territories was established. The highest efficiency of mineral fertilizers is established for cereal crops on the soddy podzolic and grey forest soils. 3571

FARIA, C. M. B. de *et al.* — **Sorption of P in five Dark Red latosols of the state of Minas Gerais: influence of some factors.** *Rev. Ceres*, 1976, 23, 166-79 (Pt, en).

Samples of these soils were submitted to treatments with Cl sodium dithionite and ammonium oxalate in order to remove exchangeable Al, free Fe oxides and amorphous oxides of Al and Fe respectively. The Al, Fe and P were determined in the soil extract for each of the above treatments. The Langmuir equation was used to estimate the maximum capacity or sorption by P. The specific surface was determined, and fractionation of inorganic P was done for samples treated with reagents as well as untreated samples. Considerable reductions of the maximum buffer capacity of P were observed after the removal of amorphous oxides of Al and Fe with ammonium oxalate. Similar results were observed when the free Fe oxides were removed by sodium dithionite, but to a lesser extent.

On the other hand, the removal of exchangeable Al by KCl altered slightly the intensity of the processes of P sorption. (R) 3817

FÜLEKY, G. — **Changes in P status in long-term field experiments. II.** *Agrokém. Talajt.*, 1975, 24, 291-302 (Hu, en, de, ru) (*Soils & Fert.*, 1976, 39, 11, No. 6753).

The soil P status and changes due to P fertilizing were investigated in soil samples taken from long-term field experiments in various regions. The amounts of total, inorganic, organic and available P were correlated with pH and $CaCO_3$ content, but not with humus or the clay-sized fraction. Fertilizer-P was incorporated mainly into Al-P (fraction II) and Fe-P (III) in a non-calcareous soil, and into adsorbed P (I), Al-P and difficulty-soluble Ca-P (IV) in calcareous soils. 3745

GUERRERO RIASCOS, R. *et al.* — **Forms of P and P fixation in volcanic soils of South Colombia.** *Inf. Conf. Cursos Reuniones (IICA)*, 82, 59-81 (Es) (*Abst. Trop. Agric.*, 1977, 3, 2, No. 12781).

The results of the study of soils in the 4 natural regions of Narino, South Colombia, indicate that Fe, Al and most phosphates are dominant over organic and Ca phosphates. Fe-P and Ca-P tended to increase with soil depth whereas Al-P was independent of this variable. The P retention capacity was very high, partly by adsorption, partly by precipitation reactions. Available P was mainly related to Ca-P. The Bray II method seems the most suitable for determination of available P in these soils. 3760

HAGERMANN, O. & MULLER, S. — **Investigations regarding the effect of the pH value on the utilization of fertilizer P and on the mobilization of soil P.** *Arch. Acker- u. Pflanzenbau u. Bodenkd.* 1976, 20, 11, 805-15 (De, en, ru).

Before the beginning of pot experiments each with four different P fertilizer quantities and with the application forms "admixed" and "placed", resp., five different soils were adjusted to pH 4...5 and 5...7. The changing P availability was measured by crop yield and P extraction, and the variations in the size of individual inorganic P fractions was followed up by way of fractionation according to Chang & Jackson. In spite of the relatively short action period, the changes in pH value produce an obvious effect on soil P availability. An increase in pH values causes the utilization of the P from the NH_4F fraction to improve, whereas a decline in pH value would stimulate the utilization of P soluble in H_2SO_4. The P from the P NaOH fraction shows largely indifferent behaviour. P accumulation in the soil due to the increase in P fertilization concerns first of all the NH_4Cl and NH_4F fractions. P placement often results in a distinct accumulation of easily available P as compared with the "admixed" variant. The abrupt changes in pH value do not impair crop yields. The question arises in how far variations in pH values may help through the mobilization effect to improve the usually rather low rates of fertilizer P utilization without crop yield being adversely affected. 3670

HOLFORD, I. C. R. — **Soil properties related to P buffering in calcareous soils.** *Comm. Soil Sci. & Plant Anal.*, 1977, 8, 125-37 (En).

In a group of 24 related calcareous soils, derived from Jurassic oolitic limestone, there was a marked variability (13-fold) in P buffering when expressed as the maximum buffer capacity. This variability was most closely related to the Fe content and pH of the soils, and these together accounted for 72 % of the variance. This percentage was not increased by including $CaCO_3$ content or OM, which were also correlated with the maximum buffer capacity. The equilibrium buffer capacity, which is the traditional measure of P buffering, was less variable but quite unrelated to all the soil properties measured except the soil surface area. However the maximum buffer capacity and quantity of adsorbed P together accounted for 63 % of the variance in this parameter. (R) 3729

IVANOV, P. — **Uptake of soil and fertilizer P in connexion with the determination of the A-value. I. Effect of the amount of soil, the plant species, and the P source.** *Soil Sci. Agrochem.*, 1976, 11, 48-54 (En) (*T.V.A. Fert. Abst.*, 1977, 10, 6, No. 1256).

The effects of the amount of soil, plant species, and P salt on the uptake of soil and fertilizer P and A-values were determined in soils with different amounts of available P. With the decrease in the amount of soil in a pot experiment, a more intensive P uptake occurs and the ratio between soil and fertilizer P in the plant changes in favor of the former source. As a result, higher measurements for the A-value were found. When different plant species were compared, an increasing share of the soil P is established in the following order: oats, sunflower, lucerne and peas; the A-value changes in the same way. When various phosphate salts are compared, A-values are obtained which are inversely proportional to the absolute amounts of their uptake by the plants. The standardization of pot experiments with respect to the amount of soil, the plant species, and the fertilizer rate is a necessary precondition to obtain repeated and comparable results for the A-value. 3826

KUDEYAROVA, A. Y. & TRUBIN, A. I. — **Some aspects concerning fertilizer P fixation.** *8th Int. Fert. Congress, Moscow*, 1976, 1, 229-36 (Ru).

In the seat of the double SP introduction into acid soddy-podsolic soil amorphous Al phosphates are formed with a small amount of a cryptocrystalline phase of the variscite group mineral (a metavariscite with a cristobalite structure). The process of crystallizing of amorphous phases takes a long time. Taking into account the quick precipitation of Ca phosphates of the type of monetite and brushite during fertilizer dissolving the presence of P compounds directly close to the double SP granules should be considered. 3577

METWALLY, A. I. *et al.* — **Salt effect in relation to NO_3 and P uptake as affected by soil texture.** *Agrokém. Talajt.*, 1976, 25, 87-95 (Hu, en, fr, ru) (*Abst. Trop. Agric.*, 1977, 3, 3, No. 13314).

Pot experiments were conducted with barley, maize and broad bean to study the uptake of NO_3-N and PO_4 from sand-soil mixtures having progressively lower cation exchange capacity (CEC). The results showed that, as soil CEC was reduced by 20 % by mixing the soil with sand, $CaCl_2$ treatment at rates of 1-6 me/100 g soil considerably increased the uptake of both N and P by barley. Further decrease of

soil CEC by 40 and 60 % reduced dry weight and uptake of N and P, but the nutrient values were still considerably higher than those of the control. The decrease in N and P contents was attributed to the progressive reduction in the soil's native N and P supply in addition to the increase in the effective salt concentration with sand % in the soil-sand mixture. Similar results were obtained with maize and broad beans concerning the N uptake. The uptake of P was, however, considerably reduced when increasing portions of sand were mixed with the soil. (R) 3807

MOHANTY, S. K. & PATNAIK, S. — **Effect of submergence on the chemical changes in different rice soils, 2. Kinetics of P, Fe and Mn.** *Acta Agron., Acad. Sci. Hungar.*, 1976, 25, 149-53 (En) (*Abst. Trop. Agric.*, 1977, 3, 4, No. 13824).

Out of 20 soils studied, 9 soils showed quadratic change in ws P as a function of submergence. Soils having high Fe and clay content showed a logarithmic change in ws P. Available Fe was subject to an exponential type of change. Eighteen soils having low to moderate total Mn and high Fe had an exponential change in available Mn. These changes have been quantified in terms of various equations. 3810

MYSHKA, A. — **Cation exchange capacity of roots as a factor of mobilization of P from $Ca(H_2PO_4)_2$ and carbonate rendzin from soil.** *8th Int. Fert. Congress, Moscow*, 1976, 3, 140-8 (Ru).

The phenomenon of Ca dilution in tissue under the influence of P application proved to be the important factor of P fertilizer effectiveness. The ratio P_2O_5/CaO in the control plants was found to be a good index of the barley yield in the control pots and also barley response to P; the level below 0.3 was found to be critical. The soil P uptake by barley was inversely proportional to the content of the total and active carbonates in the soil, the content of humus up to 2.7 % on the contrary influenced it positively. The organic C content also produced positive effect on the fertilizer P uptake. The content of carbonates did not influence considerably the process of P uptake. The extent of Ca content change in the barley plants under the influence of P fertilizers appeared to be the decisive factor in this case. Among the plants tested barley proved to be the most responsive to P fertilizer application, while soybean was less responsive and sainfoin was not responsive at all. No considerable changes in the Ca content of DM under the influence of soil conditions and the P fertilizers were noted for both plants characterised by the high exchange capacity of the roots (soybean and sainfoin). 3599

NOVAK, B. — **Effect of inorganic N and P on the straw decomposition in soil.** *8th Int. Fert. Congress, Moscow*, 1976, 5, 129-34 (Ru).

In experiments the relationships between the straw mineralization and N immobilization were studied. Straw addition caused the N immobilization until the C: N_{org} ratio reached near 10. P addition enables better utilization of energy liberated by the substrate mineralization. That is why the straw mineralization was reduced after P application. 5.59 g C must be mineralized to immobilize 1 g N under optimum conditions (straw + N + P). 7.7 % of the total energy liberated has been used for N immobilization. The energy utilization for N immobilization dropped to 0.4 % in the straw variant without inorganic fertilizers. 3617

PAGEL, H. & VAN HUAY, H. — **Important parameters of the P sorption curves of a few tropical and subtropical soils and then evolution following P fertilization.** *Arch. Acker-u. Pflanzenbau u. Bodenkd.*, 1976, 20, 11, 765-78 (De, en, ru).

The following becomes obvious from recording over an 18-month period the P sorption isotherms (or the Q/I relations, resp.) of several tropical and subtropical soils (ferrallitic and fersiallitic soils, alluvial and mangrove soils, vertisol) and of kaolinite and montmorillonite as well as their variations due to P application:

1. The sorption curves may be recorded using the equation $Y = \sqrt{X} + b$. After having transformed the curves into straight lines it is possible therefrom (with perhaps but two P determinations per sample) to establish the soil-specific constant n — which is proportional to P buffering and to the sorption maximum — the equilibrium concentration of the soil solution, the buffering, the potential P release to the plant, and the P fertilizer supply required.

2. The maximum sorption which in the beginning declines due to P application (200 mg/kg P) again comes up to its normal value (without P application) after a time span (6...18 months) that is dependent upon both soil and water regime. The temporary rise in the intensity parameters and in P availability to the plant during that period also falls down to the initial values. (R) 3669

PEPPER, I. L. *et al.* — **Microbial inorganic polyphosphates: factors influencing their accumulation in soil.** *Soil Sci. Soc. Amer. J.*, 1976, 40, 872-5 (En).

Infrared spectra of microbially synthesized, acid labile, inorganic P compounds extracted from soils provided additional evidence that they are inorganic polyphosphates (poly-P). Incubation studies with glucose amended soils demonstrated the transient nature of naturally occurring poly-P. Experiments are reported on the conditions which optimize poly-P synthesis in soil. A 2-week incubation period (preincubation) with a source of C (2 % glucose or 4 % straw) and a further 2-day incubation period (postincubation) after adding a source of ortho-P resulted in the maximum accumulation of poly-P. The quantity of poly-P also increased with increasing rates of orthophosphate from none to 1,000 mg/g soil. Longer periods of postincubation reduced poly-P accumulation. Poly-P synthesis was greater when relatively insoluble sources of P were added to soils and accumulation followed the order: $FePO_4.2H_2O$ > RP > MCP > KH_2PO_4. These results suggest that poly-P

synthesis may accompany P solubilization in soils and be an integral part of the soil P cycle. (R) 3720

RHODES, E. R. — **Simple P sorption index on some soils of the humid tropics.** *Plant & Soil*, 1977, 46, 263-6 (En).

Non linear relationships between c/x against c, and x against x/c at low equilibrium concentrations were obtained for some Sierra Leone soils: where x = P sorbed, mg/100 g; c = equilibrium P concentration, μmol/l. A single point index correlated well with isotherm slope; one of the uses to which this index can be put was illustrated. (R) 3782

ROMANOV, V. I. & SUKHIKH, V. G. — **Kinetics of available P in derno-podzolic soil and its uptake by plants in relation to ploughing depth and fertilizers.** *Agrokhimiya*, 1976, 6, 15-20 (Ru) (*Soils & Fert.*, 1977, 40, 3, No. 951).

The turning of soil surface into the deeper layers of soil during amelioration of derno-podzolic soils decreased contents of available P_2O_5 in the top 20 cm layer and increased them in the 20-40 cm layer, which slowed down the rate of P uptake by plants of red clover, potatoes and winter wheat. Application of f.y.m. and/or NPK was more important than ploughing during amelioration of derno-podzolic soils in increasing yields of these crops. 3774

RYDEN, J. C. & SYERS, J. K. — **Ca retention in response to P sorption by soils.** *Soil Sci. Soc. Amer. J.*, 1976, 40, 845-6 (En).

Retention of Ca increased in response to P sorption by soils, but was independent of the amounts of added Ca. Rather constant values were obtained for the molar ratio of Ca/P retained (0.19 to 0.34). Retained Ca was essentially recovered in 1*M* KCl washings in contrast to the fractional recovery of sorbed P. The retention of Ca in response to P sorption by soils is interpreted as arising from a sorption rather than a precipitation reaction, and results from the increase in negative charge induced by P sorption (R) 3719

RYDEN, J. C. *et al.* — **Effects of ionic strength on chemisorption and potential-determining sorption of P by soils.** *J. Soil Sci.*, 1977, 28, 62-71 (En).

Amounts of inorganic P sorbed by two unfertilized soils, during times less than required to reach equilibrium were affected by the ionic strength and cation species of the matrix solution. For non-equilibrium conditions the amounts of P sorbed increased with increasing ionic strength and were greater with Ca^{2+} than Na^{+}. For higher P additions, resulting in equilibrium solution P concentrations greater than 30 to 40 μmole l^{-1}, the effects of the matrix solution on P sorption were maintained at equilibrium, whereas at lower P additions the dependence of sorption on matrix solution composition was eliminated at equilibrium. Equilibrium sorption isotherms for each soil and matrix solution were described by three Langmuir equations, which corresponded to distinct concentration ranges or regions (I, II and III) on the overall isotherm. The free energies of sorption (ΔG) for each region were essentially independent of the soil matrix solution. The sorption maxima for regions I and II of the isotherm for a particular soil were also virtually independent of the matrix solution used. The sorption maximum for region III, however, was markedly dependent on the matrix solution, implying a potential-determining (p.d.) sorption mechanism. (R) 3823

RYDEN, J. C. *et al.* — **Mechanisms of P sorption by soils and hydrous ferric oxide gel.** *J. Soil Sci.*, 1977, 28, 72-92 (En).

Data for the sorption of added inorganic P by contrasting soils and iron oxide gel were resolved by a method of successive approximation of the Langmuir sorption constants. Three distinct Langmuir equations described the overall isotherm irrespective of the experimental conditions used. Free energies of sorption (ΔG) for a particular region were similar for each soil and for iron oxide gel under all experimental conditions. In contrast, the sorption maximum for each region was influenced by the sorbent and experimental conditions. Because of the pronounced similarities in their P sorption characteristics iron oxide gel was used as a model surface for P sorption by soils. Three mechanisms for P sorption by iron oxide gel and by soils are proposed: (i) chemisorption at protonated surface sites, (ii) chemisorption by replacement of surface hydroxyls, and (iii) a more physical sorption of P as a potential-determining ion. (R) 3824

SARKADI, J. *et al.* — **Correlation between amounts of applied P and its balance in the soil.** *8th Int. Fert. Congress, Moscow*, 1976, 5, 35-42 (Ru).

The report is dealing with the fate of the fertilizer P-residues. The results of long-term field experiments prove that the more positive the P-balance of a soil the more its P supply increases, that means the less fresh P fertilizer is needed to reach a maximum crop yield. In a trial on a calcareous chernozem 40-60 kg/ha P_2O_5 maintaining an equilibrium was enough to get the maximum yield provided that in the previous years the P_2O_5 remaining in the soil reached about 400 kg/ha. The changes in the P supply within a certain soil type caused changes in the values of AL and $NaHCO_3$-soluble P. In field experiments on some Hungarian variants of chernozem and on brown forest soils, 100 kg P remaining in the soil increased the AL- and $NaHCO_3$- soluble P content by 7-15 and 4-6 ppm, resp.. Results of pot experiments with soils of different characteristics proved that pH and silt content exerted a smaller influence on $NaHCO_3$-soluble P than on AL-soluole P. That was why $NaHcO_3$-soluble P showed a better correlation with the P-uptake of plants than AL-soluble P. 3618

SELFO, A. M. M. R. — **P reaction products in Eufaula soil.** *Diss. Abstr. Int. B 37*, 1977, 9, 4263-4 (En) (*T.V.A. Fert. Abst.*, 1977, 10, 6, No. 1257).

A greenhouse study was conducted in order to characterize P fixation products unrecovered by P fractionation in Eufaula soil. Eight replications each of 0, 10, 25, 50, 75, 100, 150, 200, 250 and 300 ppm P as $Ca(PO_3)_2$; $Ca(H_2PO_4)_2$; K_2HPO_4; KH_2PO_4; $(NH_4)_2HPO_4$; $K_4P_2O_7$; APP (granular 15-62-0); APP (liquid 11-37-0); and phosphoric acid, 0-72-0; were applied to Eufaula soil. Three crops of Sugar Drip sorghum were grown on four replications of each rate, the remaining four replications were maintained at near field capacity moisture level for 6 months. The modified Chang & Jackson's soil P fractionation procedure gave reasonable recoveries of applied P. The sum of NH_4Cl-P and Al-P fractions from the fractionation procedure was highly correlated with DM yield response of sorghum and also with available P determined with the Bray 1 20:1 procedure. The sum of NH_4Cl-P and Al-P could be used, therefore, as a good measure of available P in Eufaula soil. The fractions of Fe-P, Ca-P and occluded Fe-P were available to promote plant growth to a very much lesser extent. Sorghum was found to respond to P fertilization on Eufaula soil excepting for $Ca(PO_3)_2$ at all rates due to its very low solubility, and high rates of $(NH_4)_2HPO_4$, 15-62-0, 11-37-0 and 0-72-0 due to a salt effect and acidity effect. The ratio of Al-P:Fe-P generally increased with increasing fertilization rate and decreased with time due to conversion of NH_4Cl-P and Al-P to Fe-P. The added P were converted to NH_4Cl-P, Al-P, Fe-P, occluded Fe-P and Ca-P. With soluble fertilizers most of the conversion was first to NH_4Cl-P and Al-P. These two fractions were decreased sharply by cropping and time due to the depletion of these compounds by the crop and by the conversion to Fe-P and occluded Fe-P. There was not much change in Ca-P due to its initial low content in Eufaula soil and the low pH of the soil. 3827

SINGH, B. B. & TABATABAI, M. A. — **Effects of soil properties on P sorption.** *Comm. Soil Sci. Plant Anal.*, 1977, 8, 97-107 (En).

Study of the effects of the chemical and physical properties of surface and subsurface soils of a temperate region on P sorption from solutions containing various concentrations of P. Results showed that $Na_2S_2O_4$-extractable Fe and Al of surface soils were significantly correlated with P sorption from a solution containing 10, 15, or 20 ppm P. The relationships between the amounts of P sorbed and the other properties of the surface and subsurface soils studied (e.g., pH, organic C, soluble P, CEC) were influenced by use of 0.01*M* $CaCl_2$ as an equilibrating solution. The values of P adsorption maxima calculated from soil-water systems were from 1.2- to 2.1-fold higher than those calculated from soil-0.01*M* $CaCl_2$ systems. But the Langmuir adsorption constants calculated from results obtained in the presence of $CaCl_2$ were from 7- to 27-fold higher than those in the absence of salt. (R) 3728

STEELE, K. W. — **Effect of added P on the availability and forms of P present in two soils of the Manawatu-Rangitikei sand country.** *N.Z.J. Agric. Res.*, 1976, 19, 443-9 (En).

The changes in availability and forms of P over a 12-month period after the application of SSP to pasture on Foxton black sand and Pukepuke brown sandy loam were studied. Differences were large between the two soils in P sorption capacity, retention of applied P and relative size of the inorganic P fractions. Decline in availability of P after application could largely be attributed to its removal from the upper 5 cm of the Foxton soil, but in the Pukepuke soil, conversion of applied P to sparingly soluble forms was the major factor involved. (R) 3733

SZEGI, J. *et al.* — **Influence of fertilizers on biological activity of soil.** *8th Int. Fert. Congress, Moscow*, 1976, 5, 143-50 (Ru).

In field experiments on a calcareous chernozem, 100 kg/ha N resulted in significant increase in the cellulolytic activity of soil. 500 kg/ha P_2O_5 proved to be optimal for cellulolytic activity, while higher rates were less effective. The same is true for K added alone. However, according to factorial treatments, the high rates of P and K decreased the cellulolytic activity in comparison with low rates. The interaction of P and K seems to be the main cause. The yield of test plant (winter wheat) was correlated significantly with the cellulolytic activity of the soil. 3619

TEMPLE-SMITH, M. G. & MENARY, R. C. —**Movement of ^{32}P to roots of cabbage and lettuce grown in two soil types.** *Comm. Soil Sci. Plant Anal.*, 1977, 8, 1, 67-79 (En).

For both species 4-5 fold differences in the maximum P depletion zone diameter were observed between krasnozem and podzolic soils, the krasnozem, with the higher P sorption capacity producing the smaller depletion zone diameter. Rate of radial spread of the depletion zones was used to determine the apparent P diffusion coefficients (D values) and on this basis D values for the podzolic soil were 28-35 times those of the krasnozem.

Within any one soil type there was little difference between species in the maximum diameter the depletion zone attained; however species differences in the rate of radial spread of the depletion zone resulted in cabbage having a greater D value than lettuce in each soil type. For plants in podzolic soil the depletion zones were equivalent to the diameter of the root hair cylinder, but plants in the krasnozem soil produced depletion zones only slightly greater than the root diameter although root diameters and root hair lengths were similar in both soil types. (R) 3841

TIWARI, R. C. & MOHAN KUMAR, B. — **Effect of fertilizers on the availability of native Cu and Zn in different soils.** *Fert. Techn.*, 1976, 13, 30-3 (En).

A soil incubation study was carried out to determine the effect of different NPK fertilizers on the availability of native Cu and Zn in different soils, viz. peaty, red and alluvial. The available Cu content was not significantly affected by the recommended doses of fertilizers, whereas application of these fertilizers, particularly those containing P, reduced significantly the available Zn. Regarding the availability of Cu and Zn as affected by fertilizer addition, all the soils behaved in a similar manner except that the influence of individual fertilizer was not very much pronounced. (R) 3788

WHITE, R. E. & TAYLOR, A. W. — **Effect of pH on P adsorption and isotopic exchange in acid soils at low and high additions of soluble P.** *J. Soil Sci.*, 1977, 28, 48-61 (En).

Measurements of equilibrium P concentrations, adsorbed P and isotopically exchangeable P (E_t)) were made on suspensions of acid soils at initial P concentrations ranging from 1 to 1000 μM and pH values between 4.2 and 6.8. At low P concentrations (1-100 μM), the affinity of the adsorption reaction was greatest at pH 5.2-5.5. This result was interpreted in terms of the formation of basic Al-phosphates of varying composition that depended on the OH/P ratio in solution. At the highest P concentrations (1000 μM), when the affinity of adsorption was least at pH 5.2-5.5, it appeared that basic Ca-phosphates were precipitating at pH values > 5.5. In suspensions containing 1-100 μM P initially, values of E_t did not change consonantly with values of adsorbed P over the pH range 4.8 to 5.5. It is suggested that the E_t values were underestimated due to the presence of labelled complexes in solution which were detected by scintillation counting but not by the analysis for orthophosphate. Evidence from solution studies (White *et al.*, 1976) suggested that as much as one-third of the P could be complexed with Al in solutions between pH 4.7 and 5.4 at P/Al mole ratios of 0.075 to 7.5. (R) 3822

b. PLANT-SOIL RELATIONSHIPS

SMITH, O. L. — **N, P, and K utilization in the plant-soil system: an analytical model.** *Soil Sci. Soc. Am. J.*, 1976, 40, 704-14 (En).

Starting from specified natural or artificial sources in the soil, element transport to root absorption surfaces was modeled in terms of diffusion, mass flow, and soil buffering mechanisms. Element uptake was described by carrier theory formalism, and assimilation was based on four premises about the roles of N, P, K and photosynthate in cell chemistry. There were three main objectives of the model: 1) to predict the first-order interactive growth response of particular plant species to any combination of these macro-nutrients supplied in the soil medium. Species parameters required by the model include root absorption rate and certain cell chemistry reaction rates; 2) to make the model sufficiently general to describe a broad range of species. It was built upon common denominator principles of physiology condensed from available experimental data on corn, bean, pine, etc.; 3) to use the model to test several well-known theories of plant growth.

The model was validated against reported experiments on ryegrass, oats, a legume (*Stylosanthes humilis*), and rutabaga, in which DM yield was measured as a function of factorial application of N, P and K to the soil. The model shows that much of the deficient, optimal, toxic, and interactive response of plants to N, P and K can be explained in terms of strong linear response of cell chemistry to low nutrient concentrations and inhibition by N, P and K at high nutrient concentrations. Applying the model in a test of plant response to suboptimal nutrient concentrations, the model strongly confirms the Liebig Law of the Minimum and refutes the opposing multi-limiting-element Baule Product Law. The model also shows that the Liebig theory of linear growth response to nutrient concentration and the opposing, nonlinear Mitscherlich Law of Diminishing Return are not necessarily in disagreement, but rather may apply to different parts of the nutrient concentration range. And the model confirms that the effects on growth of N, P and K levels are more often additive on the reciprocal scale than on either the logarithmic or untransformed scales. (R) 3722

WINTER, W. H. & GILLMAN, G. P. — **Plant nutrition studies on some yellow and red earth soils in northern Cape York Peninsula: 2. P: plant response and soil retention.** *Austr. J. Exp. Agric. An. Husb.*, 1976, 16, 542-8 (En).

The response of a *Stylosanthes guyanensis/Brachiaria decumbens* pasture to P on a yellow earth soil in northern Cape York Peninsula was studied over three years. Establishment rates of 0 to 130 kg/ha P were used followed by various combinations of 0 or 20 kg/ha P in the next two years. With comparisons made at the same cumulative P rate the DM and N yields were not affected by timing of application but P yield was increased in the third year when P was freshly applied. The DM yield response was modified by the botanical composition of the pasture. In the first year the pasture was 90-95 % legume and 110 kg/ha P was required to give 90 % of the presumed maximum yield whereas in the third year when the legume content was lower (increasing from 10 to 40 % with P rate) this requirement had been reduced to about 90 kg/ha P. The third year P yield data were used to show that the value of applied P declined by about 70 % each year. After three years all the applied P was recovered in the 0-60 cm zone and the distribution was not affected by timing of application. In the 0-10 cm zone the acid extractable P increased from 0 with no P applied to 40 ppm with 150 kg/ha P applied. (R) 3726

III

PLANT NUTRITION AND PHYSIOLOGY

BARSHYAK, T. — **Effect of P on N fertilizer nitrification.** *8th Int. Fert. Congress, Moscow,* 1976, 5, 3-9 (Ru).

Data of comparative studies on nitrification rate of AS, urea and AP are given in the paper. The fertilizers were incubated with soil under field and laboratory conditions. It was found that in soils of fine mechanical structure nitrification of AP was slower than that of urea and even AS. This was not so in case of sandy loams. The use of TSP in combination with urea and AS brought a decrease in nitrification rate of the fertilizers, though the difference was not significant in some combinations. After two weeks of pot experiments when fertilizers were incubated with soil, N leaching in case of AP was less than in case of urea or AS. Correspondingly, AP application had a better effect on yield of Italian rye-grass. The effect of AP was similar to the effect of AS in combination with TSP. 3613

BOLE, J. B. — **Uptake of ^{3}HHO and ^{32}P by roots of wheat and rape.** *Plant & Soil,* 1977, 46, 297-307 (En).

Direct measurements were made of ^{3}HHO and ^{32}P taken up from labelled soil by roots of wheat and rape. Single roots were encased in labelled soil for 3 days, and the amount of ^{3}HHO and ^{31}P retained in the shoots was determined. Plants were grown to five stages of maturity in growth boxes under controlled conditions. Roots were labelled at up to four depths (to 90 cm) depending on the rooting depth at each stage of maturity. Uptake of ^{3}HHO per unit length of root increased as the plant age increased, while uptake of ^{32}P decreased to below detection levels by 45 days after germination. Larger amounts of both nutrients were translocated to and retained in the shoots from surface roots than from roots located deeper in the soil although the soil was uniform in temperature, bulk density, and composition throughout the growth boxes. Wheat roots were more efficient than rape roots in absorbing ^{3}HHO; however, rape roots took up larger amounts of ^{32}P per unit length of root. Neither native nor added P located more than 30 cm deep is of much importance to these annual crops, since uptake is minimal and the main demand for this nutrient occurs at early growth stages when the root system is restricted to the surface layers. (R) 3783

CAASSEN, N. & BARBER, S. A. — **Simulation model for nutrient uptake from soil by a growing plant root system.** *Agron. J.,* 1976, 68, 961-4 (En).

A computer program was written for solution of the mathematical model. The factors required in the model from the soil are: effective average diffusion coefficient, initial nutrient concentration in solution, and buffering capacity. For the plant they are: the relation between nutrient concentration in solution and net influx into the root, water influx, root radius, initial root length, and rate of root growth. The model was tested for measuring K uptake by corn from eight different soil-K combinations. The corn was grown in a growth chamber and K uptake was measured for the period of plant growth from 4 to 10 and 13 days. The calculated uptake, x, was correlated with observed uptake, y, by the equation $y = 0.155 + 1.566\,x$ ($R^2 = 0.87$) where y and x are μmoles of K/plant. Calculated uptake was overestimated by about 50 %, possibly because competition occurred between roots for soil K and K was not absorbed by the root as fast at night as in the day. (R) 3737

COIC, Y. & LESAINT, CH. — **Influence of the type of P deficiency on the balance photosynthesis, protidosynthesis.** *C. R. Ac. Agric. France,* 1976, 62, 17, 1251-6 (Fr).

Two types of P deficiency were studied:

1. Extended deficiency period, found in soils low in available P.
2. Sudden stop of P supply.

Regarding the former, the lack of P considerably decreased grain yields $\frac{71}{17} = 4.2$ approx., as a result of the reduction in net photosynthesis. It also reduced the protein production in the grain $\frac{5.67}{2.32} = 2.45$. But it was found that the protidosynthesis was much less affected than the photosynthesis, which resulted in a substantial increase in the protein content of the grain $\left(\frac{2.78}{1.63} = 1.7\right)$. This can be explained by the fact that the roots which take up some P regularly are much less affected by the deficiency than the tops since the roots deliver very little P to the tops. On the other hand, the tops supply roots with carbohydrates used in the root metabolism, less affected than that of the leaf. According to the type of P deficiency, the effect on the balance photosynthesis-protidosynthesis can be reversed, e.g. the deficiency affects more one or the other of these two essential functions. 3842

EDWARDS, J. H. & BARBER, S. A. — **P uptake rate of soybean roots as influenced by plant age, root trimming, and solution P concentration.** *Agron. J.,* 1976, 68, 973-5 (En).

The objective of this research was to measure the P influx kinetics of intact soybean roots. Experiments were conducted with soybeans ranging in age from 18 to 74 days. Rate of P depletion from solution vs. P concentration in solution was used to determine maximum P influx, I_{max}; Michaelis constant, K_m; efflux, E; and the lowest level to which the plants can reduce P concentration in solution, C_{min}. The effect of increasing plant P requirement per m of root length on P influx kinetics was studied by removing

half of the roots 2 days before influx measurement. Average I_{max} for P decreased with increasing plant age; however the rate of decrease was less than previously observed with corn. Trimming roots increased I_{max} of 18 to 35-day-old plants so that P uptake per plant on trimmed plants was similar to that for untrimmed plants. Both K_m and C_{min} values increased with plant age. Root trimming had little influence on K, and E was not influenced by plant age or root trimming. P influx kinetics of soybean roots as affected by plant age and root trimming were different from those observed for corn so that P fertilization practices that give the highest efficiency for use of applied phosphate may differ for the two crops. (R) 3738

KAPOOR, A. C. & GUPTA, Y. P. — **Changes in proteins and amino acids in developing soybean seed and effect of P nutrition,** *J. Sci. Fd Agric.*, 1977, 28, 113-20 (En).

Two varieties of soybean (Bragg and Punjab-I) grown in pot culture with three levels of P were studied for the changes in protein content, ether extract, amino acids and protein fractions during the development of the seed, and the effect of P nutrition thereon was also studied. The non-protein N which formed a substantial portion of total N at early milky stage, decreased and true protein increased as the seed matured, but crude protein did not seem to alter much during the seed development, whereas ether extract gradually increased with maturity. The concentrations of free amino acids such as lysine, hydroxy-proline and tryptophan decreased whereas those of glutamic acid and alanine increased as the seed approached maturity. However, the total concentration of methionine and tryptophan in the protein of the seed was not much affected by maturity. The albumin fraction decreased from the early milky stage to the maturity stage. Glutelin rapidly increased from the early milky stage to mid-milky stage and sharply declined at the mature stage whereas the glycinin fraction rapidly increased from mid-milky to the mature stage of seed development. The prolamine fraction did not vary during seed development. P application increased crude protein and true protein and decreased ether extract but had little effect on amino acids and protein fractions. (R) 3756

KHAN, A. A. & ZENDE, G. K. — **The site for Zn-P interactions in plants.** *Plant & Soil*, 1977, 46, 259-62 (En).

Zn and P contents of the different parts of maize and wheat plants, grown under controlled conditions in two diverse soil types of Maharashtra, viz vertisol and ultisol, were determined and correlated, so also the mobility ratios of Zn and P in both crops worked out. Increase in the negativity of 'r' values from roots to the leaves and the depression in the mobility of Zn and P due to their reciprocal applications, revealed that the Zn-P interactions originate in the plant roots, thereby retarding the translocation of each other to upper plant parts. (R) [3781

LOGANATHAN, S. & KRISHNAMOORTHY, K. K. — **Total uptake of nutrients at different stages of the growth of groundnut and the ratios in which various nutrient elements exist in groundnut plant.** *Plant & Soil*, 1977, 46, 565-70 (En).

A pot experiment was conducted with groundnut crop in two red soils with various levels of application of Ca, P, K and Mg. The plants were analysed at vegetative, reproductive and post harvest stages for the uptake of nutrients. Up to vegetative stage, the crop absorbed 10 % of the total requirement of N, P, Ca and Mg. During the reproductive stage the crop removed about 40 to 50 % of the above nutrients. Between reproductive and harvest stages groundnut absorbed the remaining amount of the nutrients. (R) 3787

MATHAN, K. K. & AMBERGER, A. — **Influence of Fe on the uptake of P by maize.** *Plant & Soil*, 1977, 46, 413-22 (En).

Experiments were carried out with maize in solution culture at three different Fe levels at each of which P solubilities were varied though a relatively wide range (up to 80 %). Studies were made of the interactions between Fe and P in their effects upon the DM production, Fe and P uptake. The results revealed that Fe above 5 mg/l adversely affected the growth as well as P uptake. At higher P solubility levels, translocation of Fe from the roots to the shoots was reduced, indicating an internal inactivation of Fe by the P. (R) 3786

PROKOFIEVA, M. S. — **Studies with radioisotopes of mineral element translocation in plants.** *8th Int. Fert. Congress, Moscow*, 1976, 2, 210-8 (Ru).

This paper describes radiometric methods for determining the uptake time of labelled elements by the shoot system of the plant and their rate of translocation along the stem. The rate of translocation of labelled P along the stem of sunflower and beans, in relation to different conditions, was determined with such methods (by using two automatic radiometers and multichanel recording radiometer ZAR and RAR). Uptake time of labelled elements by the shoot system of sunflower and beans was determined at different stages of growth. In addition the "labelled waves" methods of determining the time of translocation of labelled P along the stem with the help of automatic radiometers is presented.

The sorption-dynamic model of translocation of labelled elements in the conduction elements of plants was confirmed experimentally. 3593

RICHTER, D. *et al.* — **The P and K nutrition of plants as influenced by the nutrient content of the subsoil (21 to 40 cm).** *Arch Acker-u. Pflanzenbau u. Bodenkd.*, 1977, 21, 239-47 (De, ru, en).

The authors carried out pot experiments with soil layers containing different amounts of P and K, and

used data from long-term experiments with increasing levels of N and K fertilization. According to the results obtained, P and K content of the subsoil is important for the nutrition of plants and thus also to yield formation above all in those cases where the topsoil (0 to 20 cm) contains but small amounts of the above elements (low critical range for the DL method). Both with rising P or K quantities in the topsoil and with rising levels of P and K fertilization the amounts of these elements contained in the subsoil become less important for the nutrition of plants. At low topsoil P and K contents the following critical values were established (by means of the DL method) for the subsoil: 1.5 mg P/100 g soil for all soil types, 3 mg K/100 g soil for light soils, and 4 mg K/100 g soil for medium and heavy soils. Below the critical value some extra quantity must be added to the amount of fertilizer planned. (R) 3758

SAFAYA, N. M. — **P-Zn interaction in relation to absorption rates of P, Zn, Cu, Mn, and Fe in corn.** *Soil Sci. Soc. Amer. J.*, 1976, 40, 719-22 (En).

The effects of P and Zn on growth, nutrient content in tops and roots, and the rates of absorption of P, Zn, Cu, Mn and Fe per unit fresh weight of roots for two growth periods of corn were studied in soil culture under greenhouse conditions. Visual symptoms of Zn deficiency appeared in plants when the level of applied P was raised to 75 μg/g soil. P decreased tissue-Zn concentration and Zn flux through roots. Zn-deficient plants had higher concentration of P in their tissues. P flux was mostly reduced with Zn, but during 27-48 days growth, Zn-supplied plants retained near identical rates of P absorption (approx. 14 μg/g fresh root/day) irrespective of the level of P supplied. The rate of Cu absorption was reduced with both P and Zn as the plants aged. Mn flux was initially stimulated by P but later on drastically reduced by Zn. Fe concentration in plants decreased with Zn application but significant reduction in Fe flux with Zn occurred during early growth of 25 ppm P-supplied plants only. In general, nutrient fluxes diminished with plant age. (R) 3723

SUBRAMONIA IYER, P. R. V. & SAXENA, M. C. — **Kinetic studies on the inducement in uptake and transport of P by maize as a result of pre-uptake NO_3-N supply.** *Plant & Soil*, 1977, 46, 55-67 (En).

The uptake and transport of P by 12-day old maize seedlings and uptake by excised roots of four days old maize seedlings were followed for different time intervals (ranging from 1 to 24 h in the case of intact plants and 30 to 180 min in the case of excised roots) and at different P concentrations (ranging from 0.05 to 100 m*M* in both cases) after pre-treating them with 0,5 and 10 m*M* levels of NO_3-N. The inducement in P uptake due to NO_3-N pre-treatment occurred through increased production of the carrier. Both the mechanism of transport of P to shoots and the mechanism of inducement in P transport were independent of uptake process. The mechanism of inducement in transport because of pre-uptake NO_3-N was found to differ with the site of uptake. At site 'a' (higher P concentrations), it was through an increase in the rate of dissociation of the carrier-P complex to transport more P to the shoots and at site 'b', it was through an increase in the concentration of carrier accompanied by a decrease in K_M. Studies with excised roots revealed that the mechanism of P uptake and the mechanism of inducement in P uptake due to pre-uptake NO_3-N supply were both influenced by the extent of removal of P from the roots through transport. (R) 3779

ULICEVIC, M. *et al.* — **Influence of fertilizers on P and K content of vineyard soils.** *8th Int. Fert. Congress, Moscow*, 1976, 3, 220-31 (En).

The effect of fertilizers on the content and movement of P and K in the soils of the vineyard of Titograd region (Chernogoria) in skeletal cement brown mediterranean soils was studied down to the depth of 60 cm. The experiment was carried out on the plots sown with grasses and on tilled and untilled soils with and without irrigation. The fertilizers were spread at the rate of 75 + 75 + 80 kg/ha active substances annually (1969-1972). It has been found out that application of fertilizers doubled the P content in the soil at the depth of 60 cm. Some P became non-available.

— In a surface layer of the soil at 10 cm depth on the fertilized plots a considerable accumulation of P was noticed where P content was thrice as much as in a layer at 10-20 cm depth.

— The P content in the soil on fertilized plots in the layers at 10-20 and 20-40 cm depth and even in the layer at 40-60 cm depth was higher than on non-fertilized plots with surface tillage and on not irrigated plots. 3603

WHITE, R. E. — **Studies on mineral ion absorption by plants. III. The interaction of Al, P and pH on the growth of** *Medicago sativa*. *Plant & Soil*, 1977, 46, 195-208 (En).

The effect of Al and P on the growth of lucerne was studied in nutrient solutions in which Al-phosphate did not precipitate. Al and P retained in the free space of the roots was washed out with 0.1*N* HCl/O_4 at 5°C. The inhibitory effect of Al on growth was much less at pH 5 than at pH 4.5, although 3 to 4 times as much Al was found in the roots and shoots of the pH 5 plants. It is suggested that the low toxicity of high contents of Al was due to a portion of the uptake at pH 5 being in the form of polymeric aluminophosphate complexes of low net charge density. The optimum pH for the formation and polymerization of such complexes is around 5, and their composition depends on the P/Al mole ratio of the initial solutions. Washing ^{32}P-labelled roots in unlabelled P solutions containing Ca showed that 12-43 % more of the total label diffused out of the Al-treated roots at pH 5 than from control roots. (R) 3780

IV
AGRICULTURAL VALUE OF FERTILISERS

BORATYNSKI, K. & RUZIEWICZ, J. — **The effect of multicomponent fertilizers in field experiments. IV. The effect of AP and "autumn" ammophoska.** *Pam. Pulawski*, 1975, 63, 39-66 (Pl, en, ru) (*Soils & Fert.*, 1976, 39, 9, No. 5893).

In 1 trials with winter wheat, 98 with rye and 141 with spring malting barley in 1969-71 the effectiveness of some Dutch, Rumanian and Polish DAP enriched with K salt and of the Finnish "autumn" ammophoska was similar to that of equivalent applications of urea or NH_4NO_3, granular SSP and 40 % or 60 % K salt, and tended to be slightly better. DAP not supplemented with K gave higher yields of rye and winter wheat than did urea + SSP. The equal effectiveness of ammophoska and DAP supplemented with K salt was not affected by soil pH between 5.5 and 6.5 or by the contents of available P and K in the soil. 3744

A. F. DE MELLO, F. DE *et al.* — **Residual effects of P fertilizers.** *An. Esc, Sup. Agric. « Luiz de Queiroz »*, 1974, 31, 243-9 (Pt, en).

The residual effects of P fertilizers are studied by means of ^{32}P and the Neubauer and *Aspergillus niger* methods. The highest residual effect was observed for Olinda RP, the least soluble of those studied. SP and Fertifos, a precipitated P, were similar in their residual effects. The laboratory results agree with those obtained under field conditions. (R) 3507

FORDHAM, A. W. & SCHWERTMANN, U. — **Composition and reactions of liquid manure (Gülle), with particular reference to P: I. Analytical composition and reaction with poorly crystalline Fe oxide (ferrihydrite).** *J. Environ. Qual.*, 1977, 6, 133-6 (En).

Samples of liquid cattle manure (gülle) of different maturity were collected from three sites in West Germany and analysed for several components, many of them relevant to the behaviour of phosphate in bath liquid and solid phases. When gülle solutions were shaken with iron oxide, changes of inorganic P concentration were generally very similar to those in comparable inorganic model systems. Thus, there was very little interference to sorption processes from organic components of gülle and, furthermore, no interferences developed during storage of samples at 4°C, laboratory temperature, or during incubation at 35°C for several months. Precipitation of inorganic P, normally observed in these gülle samples during shaking, was minimized by rapid removal of phosphate from solution by adsorption on iron oxide. Organic phosphate in solution constituted only about 5 % of total P and very little, if any, was sorbed from solution by iron oxide. (R) 3791

FORDHAM, A. W. & SCHWERTMANN, U. — **Composition and reactions of liquid manure (Gülle), with particular reference to P: III. pH-buffering capacity and organic components.** *J. Environ. Qual.*, 1977, 6, 140-4 (En).

pH titrations of gülle samples disclosed differences of composition related to origin, age, and storage conditions prior to collection. Buffering capacities depended partly on ammonium bicarbonate content, which fluctuated from sample to sample but increased during laboratory storage, at 4C or room temperature. Organic compounds both in solution and solid phases buffered in the lower pH ranges, in some instances having greater influence on total buffering capacity than any other factor. The nature as well as the amount of these compounds differed between samples. Many were modified or decomposed during storage at laboratory temperature. Inorganic components of the solid phase, such as NH_4, Mg, and Ca phosphates, as well as calcium carbonate, made significant though relatively minor contributions. Tyrosine was identified in gülle solutions by TLC, while other amino-acids, glutamic acid and histidine, were likely constituents. There were no simple carboxylic acid anions of the type that inhibit P uptake by Fe oxides. (R) 3793

FORDHAM, A. W. & SCHWERTMANN, U. — **Composition and reactions of liquid manure (gülle) with particular reference to P: II. Solid phase components.** *J. Environ. Qual.*, 1977, 6, 136-40 (En).

Several components were detected in the solid phase of gülle samples. Struvite ($NH_4MgPO_4 . 6H_2O$) was isolated from one sample and identified by X-ray diffraction. Its presence was confirmed in this and other samples by solubility studies, which also showed the existence of trimagnesium phosphate ($Mg_3(PO_4)_2 . 8H_2O$), octacalcium phosphate ($Ca_4H(PO_4)_3 . 3H_2O$), dicalcium phosphate ($CaHPO_4 . 2H_2O$), and possibly $NH_4CaPO_4 . H_2O$. More evidence for struvite, trimagnesium phosphate, and OCP, as well as estimates of their content in samples, was obtained from measurements of solution composition during acid titration of gülle suspensions. Organic P contents of the solid phase could be calculated from these measurements, which also showed the existence of appreciable quantities of solid NH_4 and Ca organic salts. Gülle systems were found to be in a sensitively balanced dynamic state which would respond rapidly to relatively minor changes of chemical, physical and biological conditions. (R) 3792

GALLAGHER, P. J. — **Reactions of APP with high Ca irrigation waters.** *Diss. Abstr. Inst. B* 37, 3189-90 (En) (*T.V.A. Fert. Abstr.*, 1977, 10, 4, No. 797).

Water was collected from a well in Hamilton Co., Kansas, that contained 472 ppm Ca and 127 ppm Mg. This was reacted with APP and the resulting precipitate was identified by X-ray diffraction as $Ca_2P_2O_7 . 4H_2O$ (PPT). This material was compared with APP

in a growth chamber to test its availability on two soil types using maize as the test crop. Three crops grown on the same treatments showed that the PPT (at 80 ppm P) produced slightly better crop response. Apparently the APP produced a slightly more insoluble compound than crystalline APP or APP reaction products under acidic soil pH. A second growth chamber study used the same soils but solid triammonium pyrophosphate (TAPP) was the P source. In two cropping cycles the TAPP outperformed the PPT on both soils. The use of solid TAPP, rather than liquid APP, may have altered the rate of reaction with soil compounds and improved the uptake of TAPP. A method to avoid this precipitation reaction is to acidify the APP with superphosphoric acid as described by TVA; this must be done at the application site to avoid hydrolysis of the polyphosphate. The low pH will also corrode the equipment. 3795

HUNDAL, H. S. & SEKHON, G. S. — **Efficiency of Mussoorie RP as a source of fertilizer P to guar (*Cyamopsis tetragonaloba*) and groundnut (*Arachis hypogaea*).** *J. Agric. Sci.*, 1976, 87, 665-9 (En).

In two field experiments, Mussoorie RP with or without pyrite, farmyard manure or straw was compared with CSP when applied to guar and groundnut. The treatments included rates of 10, 20 and 30 kg/ha P and were located on a soil low in available P. Mussoorie RP was 44-52 % as efficient as CSP. The incorporation of Amjhore pyrite, farmyard manure or straw in the soil with RP increased the effectiveness of Mussoorie RP. Extractability coefficient ratios obtained upon laboratory incubation of soil with CSP and RP correlated fairly well with the availability coefficient ratios obtained from measurements with plants in the field experiments. (R) 3755

HUNDAL, H. S. & SEKHON, G. S. — **Comparative effectiveness of NTP as a source of fertilizer P to berseem (*Trifolium alexandrinum*).** *J. Indian Soc. Soil Sci.*, 1976, 24, 73-7 (En).

The comparative effectiveness of NTP relative to some of the ws and the water-insol. sources of fertilizer P was studied on Tolewal loam soil, using berseem var. Mescavi (local variety) as a test crop. The different P fertilizers were applied to berseem as 0, 25, 50, 75 and 100 kg/ha P_2O_5. Taking SP as the standard, effectiveness of NTP increased with the proportion of their ws P fraction. DCP and SP were almost equal in their effectiveness. RP was the least effective source of fertilizer P. Equilibrium P potentials and extractability coefficient ratios, obtained in the laboratory, correlated with availability coefficient ratios obtained from plant attributes. (R) 3814

HUNDAL, H. S. *et al.* — **Evaluation of some sources of fertilizer P in two cycles of a paddy-wheat cropping sequence.** *J. Agric. Sci.*, 1977, 88, 625-30 (En).

This field experiment was made on Gurdaspur clay loam. Urea AP, SP, NTP containing 30 % ws P and fertilizers containing 50 and 70 % ws P prepared from NTP and SP, DCP and RP were applied to the paddy crop at the rate of 0, 15, 30, 45 and 60 kg/ha P_2O_5 and to wheat at double these rates. The cumulative yield data for paddy and wheat show a slight reduction in efficiency of P fertilizers, with the exception of DCP, as their ws content decreased below 70 %. In general, the relative efficiency of the less ws sources and of RP was considerably higher for paddy than for wheat. The results show that the relative efficiency of low ws P fertilizers increased with time. The efficiency of P fertilizers declined with the rate of their application, more so in the case of higher ws materials. (R) 3821

KARLOVSKY, J. — **Agronomic value of Calciphos, Phosphal, and red phosphorus.** *N.Z. J. Exp. Agric.*, 1976, 4, 303-10 (En).

In a long-term experiment on a yellow-brown loam of medium P status, the efficiencies of Calciphos, Phosphal, and red phosphorus were compared with SP. Calciphos and its 1 : 1 mixture with SP (equal-P basis) proved to be an efficient source of P for pasture. Though the initial efficiency of Calciphos was low it improved with time and by the fifth year was 84 % as efficient as SP on an equal-P basis. Calciphos was quicker acting and maintained higher yields than Phosphal, but the efficiency of Phosphal also improved with time. Annual applications of Calciphos and Phosphal were less effective than the same total amount in a single application, but annual applications of SP yielded more than a single dressing. Highest seasonal responses from all fertilisers, applied in spring, were obtained in summer seasons (37 % of total), irrespective of whether these were applied annually or in single applications. (R) 3757

KULYUKIN, A. N. *et al.* — **The effectiveness and availability of elemental red phosphorum as a fertilizer and as a component of P fertilizers.** *Izv. Timiryazev Selskok. Akad.*, 1976, 3, 100-4 (Ru, en) (*Soils & Fert.*, 1976, 39, 11, No. 7021).

In pot experiments, red phosphorus plus pyrites cinders was best applied to potatoes in admixture with SP, 40 and 60 % of the total P applied being supplied by the SP and red P resp. 3746

LOGAN, T. J. & McLEAN, E. O. — **Diffusion of ^{32}P from partially acidulated RP.** *Soil Sci.*, 1977, 123, 203-6 (En).

Diffusion of ^{32}P from labelled partially acidulated RP in Venango silt loam compared to that from 100 % acidulated RP was studied. The addition of 20 mg/g of unlabelled phosphate to the soil matrix resulted in increased diffusion of ^{32}P from labelled 100 % acidulated RP. (R) 3732

MAHILUM, B. C. — **Residual effects of lime, Ca silicate and phosphate in the humid tropics. 2. Influence of CEC and available nutrients.** *Philip-*

pine Geogr. J., 1976, 20, 1-14 (En) (*Abst. Trop. Agric.*, 1977, 3, 1, No. 12224).

Basic slag and lime-phosphate experiments were tried on a Hydrandept planted to sugar-cane to determine their effects on cation exchange capacity (CEC), exchangeable cations and extractable anions. Both basic slag and lime substantially increased CEC, exchangeable Ca, Mg and K and extractable P, Si and S. P applied simultaneously with lime significantly increased extractable P despite the fact that P fixation in this soil is very high. KH_2PO_4 was found a powerful extractant for Si and lime solubilized much of the soil S which moved down the profile, indicating that continuous liming may impoverish the soil of S. (R) 3806

MANOILOVIC, S. & ZERAVICA, M. — **The efficiency of water-and-citrate soluble P of complex fertilizers on chernozem and other soils.** *8th Int. Fert. Congress, Moscow*, 1976, 3, 106-14 (Ru).

The fertilizing effect of water-soluble and citrate-soluble phosphates of complex and single fertilizers was tested on three crops in pots with four different types of soil during four years of experiments. The effect of P was observed on all tested soil types. Spring oats responded the most; lucerne gave the least response. With respect to the P form it can be said that annual crops were much more sensitive to water-soluble phosphates than lucerne was. 3598

MEYER, M. *et al.* — **Effect of slurry P on crop yield, P uptake and P utilization.** *Arch. Acker- u. Pflanzenbau u. Bodenkd.*, 1977, 21, 133-9 (De, en, ru).

Pot experiments were conducted on quartz sand and on loamy sand to investigate the effect of cattle slurry P and P from MCP on the crop yield, P uptake and P utilization of annual ryegrass. On quartz sand the increase of P supply resulted in rising crop yields, with slurry P acting in a way similar to that of P from MCP. On loamy sand of adequate P status crop yields were not influenced by P application at all. Increased P fertilization caused the plant P content to go up. In field experiments conducted with different crop species on different soils additional slurry P raised the P content of the harvested material in most of the species under investigation. (R) 3730

NOVOA, F. V. & NUNEZ, R. E. — **The behaviour of five P fertilizers on three soils of Mexico with different P fixation capacities.** *Agrociencia*, 1975, 19, 69-82 (Es, en) (*Soils & Fert.*, 1977, 40, 1, No. 179).

Ammonium-urea orthophosphate (UAO), ammonium polyphosphate (APP), urea rock phosphate (URP), magnesium potassium phosphate (MgKP) and TSP were applied to a mollisol(A), andosol(B) and vertisol(C) (fixing capacities of 10, 90 and 92 % resp.) in order to assess their effect on DM yield and P absorption by Italian ryegrass. The residual effect of the fertilizers was also tested. In (A) yield increases were similar with all the fertilizers tested. In (B) and (C) after the second cutting the highest cumulative yield was obtained with MgKP. In (A) P removal by plants, throughout the five cuttings, was highest with UAO, TSP and APP. In (B), at the end of the experiment, the amounts of P removed by plants were similar for all the P sources tested, except for the URP treatments, which caused least removal of P. In (C), after the first cutting, the highest amount removed was with MgKP. In all soils the amount of residual available P after the fifth cutting was highest with MgKP and lowest with URP. 3765

ROTHBAUM, H. P. & ROHDE, A. G. — **Long-term leaching of nutrients from MgAP at various temperatures.** *N.Z. J. Exp. Agric.*, 1976, 4, 405-13 (En).

Magnesium ammonium phosphate (MgAP) and Fe-bearing MgAP (containing ferrous ammonium phosphate) were made in a pilot-plant, and pellets were prepared from these products by bonding with 10 % by weight of K sulphate. These pellets and a range of conventional ws fertilisers were leached on soil columns for 3-6 months at 23, 37 and 53° C and the leachates were analysed. N, P, and Mg leached slowly over long periods from the MgAP pellets, and aeration increased the leaching rate; only K was leached rapidly. Little Fe was leached from Fe-bearing pellets. In contrast, N, P, and K all leached rapidly from the soluble fertilisers. MgAP therefore supplies essential nutrients to the soil over extended periods. The leaching rate from MgAP was at a maximum in the temperature range 23-37° C, and decreased considerably at 53° C. These results suggest that MgAP in soil is predominantly leached by an aerobic microbiological mechanism, involving nitrification of ammonia, rather than by a solubility mechanism. (R) 3771

SINGH, D. *et al.* — **Fertilizer value of indigenous RP compared with SSP: laboratory incubation studies with farmyard manure.** *J. Indian Soc. Soil Sci.*, 1976, 24, 78-80 (En) (*T.V.A. Fert. Abst.*, 1977, 10, 2, No. 367).

Fertilizer value of indigenous RP in a slightly alkaline soil (pH 7.5) was evaluated in laboratory incubation studies. The efficiency order of the RP from different deposits was found to be Laccadive + Mussoorie + Udaipur, which was related to their citrate solubility. SSP was superior to all indigenous RP. P availability from these sources increased with the P application levels from 60 to 180 kg/ha P_2O_5, and with the incubation period up to 75 days only. Application of farmyard manure at the rate of 60 t/ha showed little effect on the availability of P from the RP. 3743

SOKOLOV, A. V. & SIDORINA, L. V. — **Effectiveness of some compounds containing N and P**

with covalent bond. *8th Int. Fert. Congress, Moscow*, 1976, 2, 177-80 (Ru).

A promising compound is the triamide of orthophosphoric acid $PO(NH_2)_3$, containing 44.2 % N, 75.5 % P_2O_5 or 119.7 % of the total N and P_2O_5. N and P concentration is even higher in phosphonitriamide: 147.2 % N and P_2O_5. Tested on serozemic soils, phosphonitriamide had the same effect as MAP. Numerous tests performed in the USSR in 1973-75 with various mono- and diamines of phosphates showed it possible to raise further P mobility in soils and get poorly retrograding phosphates, using nonionogenic compounds badly fixed by soils. Nonionogenic compounds have highest mobility in Middle Asian serozems. 3590

YANISHEVSKY, F. V. — **APP, their action in soil and efficiency in comparison with orthophosphates.** *8th Int. Fert. Congress, Moscow*, 1976, 2, 181-8 (Ru).

Regularities of the effect of APP, containing about half of P_2O_5 in the condensed phosphate form, on the alkaline soils of the USSR are examined. The reasons for a better effect on calcareous soils have been experimentally substantiated. It is recommended to produce this fertilizer for crop farming. 3591

ZAROCHENTSEV, S. G. — **Effectiveness of K metaphosphate in soddy-podzolic soil with different tillage systems.** *Moscow Univ. Soil Sci. Bull.*, 1976, 31, 58-60 (En) (*Soils & Fert.*, 1977, 40, 3, No. 1282).

For spring wheat to which NPK was applied, metaphosphate was as effective in increasing yield as was an equivalent mixture of SP and KCl. Compared with ordinary ploughing to 20 cm, deep ploughing to 30 cm with the Mal'tsev plough increased fertilizer effectiveness. 3776

V

MINERAL FERTILISATION OF CROPS

a. DETERMINATION OF REQUIREMENTS

JOHNSTON, A. E. & POULTON, P. R. — **Yields on the Exhaustion Land and changes in the NPK content of the soils due to cropping and manuring, 1852-1975.** *Rothamsted Exp. St. Rep.*, 1976, 2, 53-85. (En).

Since 1949 the Exhaustion Land at Rothamsted has shown that PK residues in soil have doubled barley yields when adequate N is given. The soil is a slightly calcareous flinty silt loam or loam over clay-with-flints (Batcombe Series).

Experiments on this site started in 1852. There are two distinct periods: 1852-1901 when fertilisers and farmyard manure (fym) were applied and residues accumulated in soil; 1902-75 when, because no P or K was given, the residues have decreased. No N was given during 1902-40 and depletion was small but since 1941 when N has been given to all plots each year more of the residues have been removed.

Yields of wheat and potatoes grown before 1902 are summarised and the P and K balance, additions minus removals, for 1856-1901 given. During 1902-40 mainly barley was grown, without fertiliser, and yields, recorded only until 1922, are summarised and estimates of the P and K removed in the crops given. Yields, recorded again since 1949, have measured the combined effects of the P and K residues accumulated between 1856 and 1901. This paper gives yields and the rate at which the residues are being released.

The effect of P residues on various P fractions in the soil in 1903 was measured as was the effect of K residues on exchangeable K. Increases in total, isotopically exchangeable and $NaHCO_3$ soluble P accounted for about 100, 45 and 15 % respectively of the estimated P residues. The increase in exchangeable K accounted for about 32 % of the estimated K residues.

Yields since 1949 can be divided according to the barley variety grown. On impoverished soil yields were much the same in each period, seasonal variations are probably due to factors other than the solubility of soil P and K. On soils with residues yields increased as more productive varieties were grown. In 1970-75 yields of Julia, grain at 85 % dry matter, were: 1.83 t/ha on impoverished soil, 4.75 t/ha on soil with fym residues, 4.22 t/ha on soil with PK fertiliser residues. The largest yield was about equal to the national average yield for all barley crops. Much of the extra yield on the enriched soil comes from the P residues but in the last five years K residues have increased yield by about 0.5 t/ha grain. At the present rate of removal the P residues could last for about 70 years.

P removed in crops since 1902 is related to changes in isotopically exchangeable and $NaHCO_3$ soluble P. Before 1958 when, for most of the time, the soils were not stressed to supply P, the decrease in isotopically exchangeable and $NaHCO_3$ soluble P accounted for about 100 and 40 % respectively of all the P removed. Between 1958 and 1974 barley, given N each year, yielded well and the decline in isotopically exchangeable and $NaHCO_3$ soluble P accounted for only about 40 and 20 % of the P in the crops. 3833

KASITSKY, Y. I. *et al.* — **Theoretical and practical aspects of phosphate distribution in crop rotation.** *8th Int. Fert. Congress, Moscow*, 1976, 1, 221-8 (Ru).

On the basis of information on action of different P rates and their residual effect on carbonate chernozem and soddy-podzolic soils, established by special experiments, a comparative efficiency of P fertilizers has been calculated for annual and periodical applications (once every 2-3 years). The conditions

of effective periodical application and optimal distribution of P fertilizers in crop rotation due to its application at different levels are presented. It is shown that rational P ferilizer distribution is an important reserve of its efficiency. 3576

NEIKOVA-BOCHEVA, E. — **Application of P fertilizers and possibilities of predicting the yield.** *8th Int. Fert. Congress, Moscow*, 1976, 4, 117-23 (Ru).

An attempt was made to predict a desirable P level under different soil conditions and P supply by a complex application of the main parameters reflecting losses of available P, such as the amount of P adsorbed at equilibrium concentration of 0.3 ppm P, P immobilization with time, the amount of P uptake. An example was given with five of the main soil types in Bulgaria at three rates of supply by previous fertilizer application. It was found that the experimental determination of the above parameters and their complex use has made it possible to establish a long-term prediction for different periods of time. 3607

NESTEROVA, S. — **Plant analysis as a base for determination of N and P fertilizer requirements of wheat.** *8th Int. Fert. Congress, Moscow*, 1976, 3, 149-55 (Ru).

It was shown that N application before tillering had an effect on the level of N in plants. At the same time the application of P increased the concentration of it in plants. As a result the P requirements of plants can be determined before tillering, but N requirements have to be determined after tillering and at later stages of development. On the basis of established optimum P and N rates the optimum correlations between these elements in leaves $\left(\frac{\%\,N}{\%\,P} = 12\right)$ and in plants $\left(\frac{\%\,N}{\%\,P} = 10\right)$ were estimated. 3600

PEREGUDOV, V. N. & IVANOVA, T. I. — **Possibility to predict the efficiency of fertilizers on the base of mathematical methods and computers.** *8th Int. Fert. Congress, Moscow*, 1976, 1, 175-82 (Ru).

The results of mathematical development of data of specially planned 81 treatments long term experiments in crop rotation with increasing rates of mineral fertilizers were summed up to determine the functions of crop rotation productivity and equations of regression, which characterize the dependence of different indices of agricultural production quality, economics and agrochemical soil characteristics upon fertilizer rates at their permanent application. 3573

RICHARD, L. — **Response curve of crop to fertilizer application.** *Cot. Fib. Trop.*, 1976, 31, 235-9 (Fr, en, es).

The action of a fertilizer, or of a single fertilizing element, is studied by applying increasing doses of it to the crop. The interpretation of the experiment should be proposed adjusting a mathematical model to the yields observed.

Theoretically the best description of a vegetable's response is provided by Mitscherlich's formula: yield = $A\,(1 - e^{-cx})$. It is possible to choose a mathematical model close to this law by a simple transformation of x, variable dose of the fertilizer experimented, into $X = e^{-x}$. A linear regression leads to the equation:

$$\text{Yield} = A - b\,e^{-x}$$

A corresponds to the maximum theoretical yield liable to be attained with the element x and b corresponds to the theoretical increase in yield.

The estimate of the true value of the regression factor b is proposed within the scope of an experiment performed by the Fisher block method. (R) 3502

STANCHEV, L. B. *et al.* — **Relationships between plant productivity and the quantity of P and K fertilizers applied in reserve.** *8th Int. Congress Fertil., Moscow*, 1976, 5, 54-60.

In a continuous fertilizer experiment carried out on a meadow swampy soil with a reaction close to neutral, the effect of P and K reserve fertilization applied either on a mineral or organic substrate (farmyard manure, straw, green manure) on both crop productivity and profitability of fertilizers was investigated. It was established that the annual application of P and K fertilizers is not preferable to the periodical one, when estimated by economical indices for the whole crop rotation. As regards the productivity of the separate crops, P and K reserve fertilization is more effective with maize, and the annual fertilization with barley, wheat, and vetch-oat mixtures. At equal and moderate rates of fertilizers ($N_{600}P_{400}K_{600}$) (applied during the whole field 6-crop rotation) irrespective of the frequency of application (annual or periodical) almost equal amounts of nutrients are removed from a unit area by the crops involved in the rotation. The utilization of the active substances incorporated by the fertilizers is almost the same.

Both commercial and organo-mineral fertilizers have a high economic effect. The means invested additionally in fertiliser are returned 1.9 to 3.8 times, the greatest return being obtained by reserve fertilization. 3615

SINGH, B. B. & JONES, J. P. — **P sorption isotherm for evaluating P requirements of lettuce at five temperature regimes.** *Plant & Soil*, 1977, 46, 31-44 (En).

P sorption curves were used to fertilize the soil with six P rates corresponding to initial sorption equilibrium solution P levels in the range of 0.03 to 0.72 ppm. Yield response to P measured for temperatures was in controlled environment chambers. Growth temperatures ranged 12.7 to 29.4 °C. Sorption

of added P and desorption of sorbed P increased with increase in temperature. Yields of lettuce increased with the increased sorption equilibrium solution P levels at all the temperatures. Initial sorption-equilibrium solution P levels necessary for 95% yield had to be increased from 0.20 to 0.64 ppm when temperature was lowered from 29.4 to 12.7 °C. Desorption-equilibrium solution P levels for 95% yield were nearly constant at all temperatures. The log of initial sorption equilibrium solution P as a function of temperature for 95% yield was linear between 17.2 and 29.4 °C. Comparison of the data for 95% yield in solution cultures showed that critical nutrient solution P levels were very close to the desorption equilibrium P levels for 95% yield of plants grown in soil at similar temperatures. Relative yields of lettuce and desorption equilibrium solution P levels showed the same trend to changes in temperature. The study suggests that the major role of temperature on P uptake between 17.2 and 29.4 °C is due to desorption of P from the soil. (R) 3778

TANDON, H. L. S. — **P In Indian agriculture.** *E.N.S.P., Techn. Bull. No. 1,* 1976, 1-62 (En).

This paper attempts to summarise the current status of the use-pattern and efficiency of fertiliser P in India. It is not an exhaustive review, but brings out some salient features using selected Indian data for illustration purpose. 3802

b. METHOD AND TIME OF APPLICATION

BONCHKOWSKI, S. A. — **Technology of simultaneous spreading of dry fertilizers.** *8th Int. Fert. Congress, Moscow,* 1976, 4, 241-8 (Ru).

A spreader for the simultaneous application of different fertilizers has been developed at the Institute of construction, mechanization and electrification of agriculture, Warsaw (Poland). The spreader can simultaneously apply fertilizers with radically different granulometric composition making them unsuitable for mixing owing to the separation of the fertilizers into layers during transportation and handling. The spreader has independent system of regulation of flow through slidevalve which provides an opportunity to apply fertilizers in any dose and proportion. The operational width of spreading is 9 to 14 m depending on the granulometric composition of fertilizers applied at a given time. This is 50 to 100% more than in ordinary disc spreaders. Uniformity of spreading achieved with these widths is at the required agrotechnological level. 3611

GORODNY, N. M. — **Theoretical principles and practice of fertilizer application for yield of high quality.** *8th Int. Fert. Congress, Moscow,* 1976, 2, 23-9 (Ru).

In order to obtain high quality grain N fertilizers should be applied in two stages, first when cultivating of soil, then in spring and summer at shooting. The outside root application of fertilizer for winter wheat by 1% liquid of urea during leaf-tube formation increases the protein content by 2-3% and raw vegetable gluten by 6-8%. One-sided P feeding in many cases lowers the protein and vegetable gluten content. By application of P or of P and K fertilizers to chernozem after bare fallow and fallow sown with perennial grasses it is possible to obtain high yield of winter wheat with high grain quality. 3580

KUSHELEVSKI, L. & LABENTOVIC, J. — **Fertilizer efficiency and its dependence on irrigation.** *8th Int. Fert. Congress, Moscow,* 1976, 3, 68-74 (Ru).

The plant yield in irrigated plots with fertilizers applied was higher than in unirrigated plots with medium and high levels of fertilizer application. The increase was 17% in case of potatoes, 19 to 21% in case of grass, 15 to 22% in sunflower, 19 to 22% in winter wheat and 9 to 10% in spring wheat and barley. Simultaneously irrigation increased productivity of 1 kg NPK applied and it improved utilization of fertilizer nutrients by plants. Nutrient requirements of plants per unit of harvested produce were less in irrigated plots. This is an expression of a better feeding regime of plants in irrigated conditions. 3597

LYNGSTAD, I. — **Placement of fertilizers for spring cereals. Experiments during the period 1966-75.** *Forskning Forsok Landbruket,* 1977, 28, 159-77 (No, en).

The effect of placement of fertilizers to spring cereals was investigated in 141 field experiments in southeastern part of Norway during 1966-75. The major part of the experiments included 3 rates of NPK-fertilizers (20-5-9) or (16-7-12), corresponding to 40, 80 and 120 kg/ha N. The fertilizer was placed at a depth of 8-10 cm with fertilizer spreaders or machines which place fertilizer and drill seed at the same time, but in separate coulters. On the average placement of fertilizer increased grain yield over broadcast application by 140 kg/ha or 4%. Yield response to fertilizer placement was highest at the second fertilizer rate. The results indicate a relationship between yield response to fertilizer placement and soil texture. On the average soils containing more than 15% clay gave a significant higher grain yield response (180 kg/ha) than soils lower in clay content (30 kg/ha). (R) 3830

MATTINGLY, G. E. G. — **Liquid NPK fertilisers for potatoes.** *Rothamsted Exp. St. Rep.,* 1976, 1, 93-5 (En).

In 1974 and 1975 several methods of applying liquids for main-crop potatoes were tested at Rothamsted and Woburn to establish whether placing a liquid fertiliser to the side of seed potatoes increased fertiliser efficiency and yield. At Rothamsted placing more than 188 kg/ha N as either of the liquid fertilisers in bands checked growth until mid-July. Leaf

analyses, made at this stage of growth, showed that % P and % K were largest where the liquid fertiliser had all been placed, indicating that these nutrients had been taken up later than on plots given other treatments. At Woburn, where the soil contains more soluble P, placing the liquids in bands did not check early growth and yields from placement were larger than from sprays and only a little smaller than from the granular fertilisers. 3832

RAUSCHKOLB, R. S. *et al.* — **Applying P through drip irrigation systems.** *Calif. Agric.*, 1976, 30, 5, 8-10 (En).

The disadvantages of clogging drip lines and assumed lack of movement have prevented the application of orthophosphate through drip irrigation systems. Orthosphosphoric acid can be applied without these disadvantages when extreme care is used. Organic phosphates such as glycerophosphate will move farther in soils, are easily applied through the drip system without clogging, and P is readily used by plants. (R) 3505

TAYLOR, B. K. & ISSELL, L. G. — **Comparative effects of foliar- and root-applied P on one-year-old peach trees.** *Austr. J. Exp. Agric. An. Husb.*, 1976, 16, 596-9 (En).

The response of one-year-old peach trees growing in sand culture to foliar applications of 1 % KH_2PO_4 given in summer, autumn, or summer + autumn after initial pH adjustment to 2.5, 4.5 or 6.5 was compared with that of controls fed ± P via roots. After one season, it was clear that foliar-applied P had been less effective than root-applied P as a means of increasing tree growth and P content. This result allied with other published information suggests that foliar applications are an inefficient means of supplying P to fruit trees. (R) 3727

WIDDOWSON, F. V. & PENNY, A. — **Results from two sets of experiments with spring barley, the first comparing injected with broadcast N granules, the second comparing injected and combine-drilled NPK solutions with broadcast NPK granules.** *J. Agric. Sci.*, 1977, 88, 35-45 (En).

Experiments compared yields of, percentages of N in, and removals of N by barley given either NPK solution fertilizers or NPK granules supplying 63 or 126 kg/ha N. One liquid (14-6-8) supplied the whole of the N and was either sprayed, combine-drilled or injected mid-way between the seed rows (15 cm apart). The other liquid (4-10-10) supplied one-fifth of the N and was either combine-drilled or injected; Nitro-Chalk supplied the remainder of the N. The granular fertilizer (20-10-10) was broadcast. The 14-6-8 solution always gave a smaller yield than comparable granules. Yields with injected dressings were no larger than with sprays, but each was safe. Combine-drilled dressings were harmful and often killed the barley and decreased yields especially when 126 kg/ha N was given. The 4-10-10 solution was harmless when combine-drilled and gave a larger yield than the granules when 63 kg/ha N was given and the same yield when 126 kg/ha N was given. It gave a smaller yield than the granules when it was injected. Grain percentage N tended to be larger with the injected liquids and smaller with the sprays than with the broadcast granules though the amount of N recovered by the barley from the injected liquids was no larger than from the granules. (R) 3734

VI

EFFECTS OF FERTILISERS ON CROPS

a. CEREALS

COUPRON, C. *et al.* — **P fertilisation of cereal crops on calcareous soils. Results of twelve years of experiments.** *C.R. Ac. Agric. France*, 1976, 62, 11, 830-40 (Fr).

The soil of this experiment was a grey rendzine, fairly representative of that kind of soil which covers about 150,000 ha in the two Charente "départements".

Five P forms and one control were compared:

- 16-18 % SSP applied in the autumn;
- 16-18 % SSP applied in the spring either top-dressed (small grain), or broadcast before sowing in the case of maize;
- 16-18 % basic slag, applied in the autumn;
- Aluminium-calcium phosphate (phospal), 34 % P_2O_5, applied in the autumn;
- Finely ground RP, 30 % P_2O_5, applied in the autumn;

During the first three years the rates applied were 160 kg/ha and they were decreased to 90 kg/ha in the fourth year.

Except for the first year which showed a positive effect of an autumn application of SSP and basic slag, no significant response of wheat and barley to any form of P fertiliser was noticed until the 7th year.

This long term experiment showed that, in clay calcareous soils of the Charente area, with an initial content of P extractable by the Joret-Hébert method of about 0.1 ‰, wheat and spring barley crops responded positively to the application of some P fertilisers (SSP, basic slag, phospal). On the other hand none of the tested fertiliser influenced maize production. However the determination of the P content in the seed of the last maize crop showed a very significant difference between the content of this nutrient in the control plants or in the plants treated with RP and that in the plants treated with the three forms of P fertilisers. 3843

DJERI, D & MATZ, G. — **Effect of P fertilizer on the content of zinc and tryptophan in maize seeds.** *8th Int. Fert. Congress, Moscow,* 1976, 5, 244-9 (Ru).

Field experiments were conducted on brown forest soils of Middle Europe to study effect of high doses of P fertilizers on Zn and tryptophan content in different parts of maize seeds. The soil in the experiments was deficient in P and Zn. Application of N and K fertilizers without P aggravated the P and Zn deficiency in this soil and brought a decrease in tryptophan content in seeds. Application of the first rate of P (70 kg/ha) resulted in increase of Zn and tryptophan content in different parts of seeds. High rates of P fertilizers brought a gradual decrease of Zn and tryptophan content in maize seeds. 3623

FAGERIA, N. K. —**Effect of P, Ca, and Mg concentrations in solution culture on growth and uptake of these ions byrice.** *Agron. J.,* 1976, 68, 726-32 (En).

Minimum concentrations required for maximum growth were 25 μM P, 250 μM Ca and 33 μM Mg resp.. At higher P concentrations a linear absorption isotherm was obtained with respect to P content in the plant tissue. The critical concentration of P in the tops of 100-day old plants was 0.4 %. To support maximum growth, Ca content varied from 242 to 2,373 μg-atoms/five plants for 25 to 125 days of growth. Maximum growth was characterized by a relative absorption (I_M) rate ranging from 14 to 320 μg-atoms of Ca/g dry weight of roots/day during the period of cultivation. To support maximum growth, plants must absorb 13.7, 7.7, 4.3, 4.0, and 2.4 μg Mg/g fresh weight of roots/h at 25, 50, 75,100 and 125 days of growth resp. With the advancement of age, P and Ca content in plants and their utilization quotients were increased but relative growth rate and rate of Ca and Mg absorption decreased. (R) 3725

Soil fertility. *Ann. Rep. 1975, Intern. Inst. Trop. Agric., Ibadan, Nigeria,* 16-21 (En).

The effect of P applied to previous maize and legume crops on an Egbeda soil series was followed up with a sweet potato crop in 1975. A significant effect of the residual P was observed on the tuber yield of cultivar Tib. 4. The amounts of P extracted with five different reagents also showed highly significant correlations with tuber yields and tissue P contents of the index leaf. Dry tuber yield gives a better correlation with extractable soil P than fresh tuber yield. Among the extractants tested, Bray 1 yielded the best correlation with tuber yield and leaf P content.

The prospect of using RP for direct application was evaluated in the laboratory and greenhouse. Laboratory incubation experiments indicated that transformation of RP varies with soil type and the solubility of RP. The availability of North Carolina rock (NCR), Morocco rock (MR), Togo rock (TR) — and CSP in Alfisols (Egbeda and Alagba soils) and Ultisols (Nkpologu and Onne soils) was investigated under greenhouse conditions. These results indicate that NCR and MR are comparable to CSP for maize on the Alfisols. On the Ultisols a longer reaction period between NCR and MR with the soil is apparently needed to mobilize the P.

When sweet potato was grown in Onne soil without liming (pH 4.30), NCR, MR and TR gave slightly better DM yield than CSP; with liming (soil pH 5.20) the differences disappeared. In contrast, P uptake differed substantially with sources. MR and TR had very little effect on plant P even at high P application rates, while the uptake from CSP and NCR increased greatly with application rates. 3511

FORDE, S. C. M. — **Effects of applied N, P and K fertilizers on the chemical compositions of the ear-leaf of maize in field trials in the Eastern Caribbean.** *Trop. Agric. (Trinidad & Tobago),* 1976, 53-4, 273-9 (En) (*Abst. Trop. Agric.,* 1977, 3, 2, No. 12927).

The effects of N, P and K at 134, 58 and 112 kg/ha resp. on the chemical composition of the ear leaf of maize were studied in 28 fertilizer trials carried out in 4 islands of the Eastern Caribbean. Sufficiency ranges for N, P and K in the ear leaf were 2.10 to 2.96 % N, 0.25 to 0.41 % P and 1.39 to 2.57 % K. Critical values for N, P and K in the Leeward islands were 2.19, 0.25 and 2.17 %, while for Dominica, these values were 2.53, 0.18 and 2.32 %. 3762

HERA, K. *et al.* — **Effect of NP fertilizers on affection of wheat by mildew.** *8th Int. Fert. Congress, Moscow,* 1976, 6, 101-15 (Ru).

It was established that on the leached chernozem-like soil of Sutchavsk plateau (Rumania) one side N fertilization is not favourable causing sensibility of plants to mildew affection, giving puny grain and yield reduction. Yearly N and P fertilization causes accumulation of nutrients in the soil that leads after 5-6 years of consistent fertilizers use to necessity of moderate application of N at rates of 40-80 kg/ha, and supporting level of P at 40 kg/ha. Yearly application of high levels of N and P fertilizers causes plants sensibility to mildew affection.

In that case combating measures against this disease should be applied or resistant varieties are essential. 3627

KAISTHA, B. P. *et al.* — **Uptake of soil and fertilizer P by wheat as affected by N fertilization.** *Fert. Techn.,* 1976, 13, 113-6 (En).

To ascertain the effect of N addition on the availability of soil as well as fertilizer P in two sierozem soils—one being low in P and the other medium—greenhouse studies were carried out with wheat as the test crop. The yield, total soil and fertilizer P uptake and per cent utilization of P were observed to be maximum by the application of 100 ppm P in combination with the same quantity of N. All other

combinations of P and N showed a downward trend in respect of the aforesaid components. The effect, however, was more pronounced in the case of medium than in the low P soil. The results suggest that the amount of free P left in soil solution, after satisfying P fixing capacity, is more important in predicting the P requirement of wheat in these soils. (R) 3789

KANG, B. T. & YUNUSA, M. — **Effect of tillage methods and P fertilization on maize in the humid tropics.** *Agron. J.*, 1977, 69, 291-4 (En).

The present study was undertaken to investigate the interaction between soil tillage and P application methods on (a) P movement in the soil profile, (b) maize root distribution, (c) P content, and (d) maize yield. The experiment was conducted on Egbeda soil series in southern Nigeria in 1974 and 1975 using a split-plot design with four replications. Root density of maize was increased with P application. There was a tendency of higher root concentration in the upper 10 cm of the soil surface with minimum tillage. Movement of broadcast P in the soil profile was observed to be slow with minimum tillage. However, broadcast, band, and hill methods of P application were observed to be equally effective in supplying adequate P to the maize crop at rates of $\geq$ 20 kg/ha P on the Egbeda soil. Therefore, no effect of P placement method on maize yield was observed with both minimum and conventional tillage methods. The lower maize yield with minimum tillage in 1974 was attributed to early N-stress. In 1975 with 160 kg/ha N, maize yield was equal with conventional and minimum tillage methods. (R) 3754

PETROVA, M. & DIMITROV, S. — **Rates and proportions of N, P and K for wheat on dark-grey forest soil in the Ludogor region. I. Effect of fertilizers on growth and development of plants.** *Rast. Nauki*, 1976, 13, 91-101 (Bg, ru, en) (*Soils & Fert.*, 1977, 40, 1, No. 222).

In trials in 1970-4 with winter wheat given 0-240 kg/ha N, 0-160 kg/ha P_2O_5 and 0-120 kg/ha K_2O in 49 combinations in addition to a reserve application of 0, 600 or 900 kg/ha P_2O_5, application of 120 and 180 kg/ha N in combination with 80 and 120 kg/ha P_2O_5 was most effective in increasing plant growth and development; P alone was less effective in increasing tillering. DM accumulation by plants was the most intensive during the period from tillering to the earing stage, when 70-90% of the total DM was accumulated; DM accumulation was highest, 8.84-9.94 t/ha, with 180 kg N + 120 kg P_2O_5 + 120 kg K_2O. Among different organs, DM accumulation was the highest, about 66% of the total, in stems of unfertilized plants; NP and NPK decreased it to 58% and increased the proportion of DM accumulated in leaves to 22% and in ears to 19%. Resistance to powdery mildew [*Erysiphe graminis*] infection was decreased in plants given N, compared with those given P. 3768

POPA, A & POPA, G. — **Wheat and maize fertilizing on slopes.** *Cereale si Plante Technice*, 1976, 27, 26-31 (Ro) (*Soils & Fert.*, 1977, 40, 1, No. 216).

On non-eroded slopes application of N_{64-96} P_{64} or of 20 t/ha farmyard manure plus $N_{64}P_{64}$ increased wheat yield by 680 and 860 kg/ha, and maize yield by 960 and 1250 kg/ha. On moderately eroded slopes wheat yield was increased by 1320 and 1650 kg/ha and maize yield by 1280 and 1580 kg/ha. On strongly eroded slopes, application of the same rates of amendments increased wheat yield by 1460 and 1620 kg/ha and maize yield by 1600 and 1980 kg/ha. On all slopes, application of 20 t/ha farmyard manure increased wheat yield by 710 and 990 kg/ha and maize yield by 1140 and 1510 kg/ha. 3766

PORANANOND, K. & SEARLE, P. G. E. — **The effect of time of fertiliser-soil contact, distance of P movement and fertiliser solubility on P availability to early growth of lowland rice.** *Plant & Soil*, 1977, 46 391-404 (En).

P availability was measured by P uptake in a glasshouse experiment in which two week old rice seedlings were transferred to the surface of fertiliser-treated soils for three weeks before harvesting. The fertilisers used in the study were MAP, APP, SP and RP. Availability of all fertilisers was tested in this way after 2, 4 and 8 weeks of fertiliser-soil contact. The results showed that at all times of measurement, the availability of the fertilisers could be ranked MAP $>$ APP $>$ SP $>$ RP. Of the 6 possible correlations between P uptake and P movement, only one was significant for the fertiliser-soil contact period of 2 weeks and P movement at 4 weeks, ($r = 0.950$, $P > 0.05$). Of the 6 possible correlations between P uptake and fertiliser solubility, none were significant. However, of the 6 possible correlations between P uptake and the product of the two laboratory parameters (referred to as the availability index) four were significant ($P > 0.05$ in all cases), and involved only the fertiliser-soil contact periods of 2 and 4 weeks. These results indicate that fertiliser solubility alone is not a satisfactory correlative determinant of availability of fertiliser P to lowland rice. P movement alone is marginally better, but the best correlations are obtained when both parameters are taken into account. While their combined effects are evident only during the first four weeks after fertiliser application, this may still be important to the successful establishment of a rice crop. (R) 3785

RACHIE, K. O. — **The millets. Importance, utilization and outlook.** *CIAT*, **Cali, Colombia-***ICRISAT*, **Hyderabad, India,** 1975, 69 p. (En) (*Abst. Trop. Agric.*, 1977, 3, 2, No. 12957).

This book deals with various aspects of millets (the term millets refers to any of the small-seeded cereal and forage grasses used for food, feed or forage). Its main contents are: description, problem of nomenclature, history and geographic adaptation, world production of millets, utilization of millets, outlook for millets, bibliography, and appendices. 3763

RECHKUNOV, N. I. — **Effect of mineral fertilizers on yield of spring wheat in the forest-steppe zone of Altai province.** *Sibirsk. Vest. Selskok. Nauki,* 1975, 5, 13-5 (Ru, en) (*Soils & Fert.,* 1977, 40, 1, No. 219).

In farm trials in 1970-2 in the Altai province, S. W. Siberia, application of various NPK rates increased average grain yields of spring wheat from 2.31 t/ha without NPK to 2.55-3.13 t; the highest yields were obtained with 40 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha. The highest yields and the highest responses to NPK were observed in the wet year 1972. NPK increased the grain protein contents from 12.9 % to 13.3-14.4 % and proportion of gluten in the protein from 25.2 % to 28.4 %. 3767

RHOADS, F. M. — **Leaf area and plant height as indicators of plant response to fertilization of corn.** *Proc. Soil & Crop Sci. Soc. Florida,* 1976, 35, 36-8 (En) (*Abst. Trop. Agric.,* 1977, 3, 2, No. 12916).

The objective of this study was to show plant response in terms of leaf area, plant height, number of silks on a given date and grain yield of corn to fertilization. Leaf area increased with fertilizer level 28 days after planting, but not at 55 days. Plant height increased with fertilizer level at 28 and 54 days after planting. Also number of ears silked per plot increased with fertilizer level. 3761

RODRIGUEZ, J. M. & LEONS, L. A. — **Fertilization of maize in black volcanic ash-derived soil of the central plain of Antioquia, Colombia.** *Inf. Conf. Cursos Reuniones (IICA),* 82, 351-63 (Es) (*Abst. Trop. Agric.,* 1977, 3, 2, No. 12966).

The black volcanic ash-derived soils of Antioquia, which have been cropped with maize during 8 consecutive years, start to show N deficiency symptoms after the 3rd harvest. The maize crop shows immediate effects upon liming (5 t/ha), and application of organic matter (4 t/ha) or of K (75 kg/ha K_2O). A high dose of P_2O_5 (400 kg/ha) is recommended, locally followed with applications of 100 kg/ha P_2O_5. In various cases there were acceptable correlations between yields and results of soil and leaf analyses. (R) 3764

SARIC, M. *et al.* — **Effect of nutrient level in soil on weight of DM and content of some ions in maize.** *8th Int. Fert. Congress, Moscow,* 1976, 6, 42-50 (Ru).

The DM weight was the highest at white and yellow lights, and it was the least at red and violet ones. For the plants growing on complete nutrient solution, the DM weight was the most, and it was the least, when the plants were growing at total lack of K in nutrient solution. The content of N, P, K and Ca depended on nutrition variants as well as on light quality. Their content was the least in plant tissues when one and the same ion was absent in the nutrient solution irrespective of the light quality. The content of N, P, K and Ca varied according to the light quality and to the content of N and Ca was the most at shorter wave lengths and the content of K at longer wave lengths, while the content of P did not show any specific correctness toward spectral light content; it was the most at green, almost the same at white and violet, and the least at blue and yellow-orange light. 3626

SINGH, R. *et al.* — **Response of dryland wheat to P fertilizer as influenced by profile water storage and rainfall.** *J. Agric. Sci.,* 1977, 88, 591-5 (En).

These effects were studied for a 2-year period (1973-5) on loamy-sand and sandy-loam soils. Plant available water at seeding varied from 62 to 205 mm, seasonal rainfall varied from 62 to 154 mm and available P status ranged from 9.5 to 18.5 kg/ha P. Four rates of 0, 15, 30 and 45 kg/ha P_2O_5 were tested. Available water at seeding, seasonal precipitation and the available P status of soil determined the yield response to P fertilizer. Response to P application was observed up to 15 and 30 kg/ha P_2O_5 in loamy-sand and sandy-loam soils resp.. Growth and yield of wheat were highly correlated with the available water at planting plus seasonal rainfall. Total water use did not change in loamy-sand soil, but it increased by 16 mm in sandy-loam soil with the application of P. The profile water depletion pattern, further, indicates that the fertilized crop used more water from layers below 135 cm in loamy-sand and 22.5 cm in sandy-loam soil. (R) 3820

SOYER, J. P. *et al.* — **Maintenance of PK status of soils with cereal crops following simple rotations (maize monoculture or wheat-maize rotation).** *C. R. Acad. Agric. France,* 1976, 62, 11, 843-59 (Fr).

The first results of a set of long term experiments, carried out in the South West of France, on the maintenance of the PK status of soils under a simple cereal rotation already show a few important points such as: in soils considered as adequately supplied with P and K, the application of PK rates equivalent to the removals multiplied by a factor of 1 to 1.5 (according to leaching and fixation hazards) seems sufficient to keep yields at their top levels and, at the same time, the initial soil fertility potential. 3844

TAKAMURA, Y. *et al.* — **The fates and balance sheets of fertilizer N and P applied to a rice paddy field in the Kasumigaura basin.** *Ibaraki Agr. Exp. Sta.,* 398-405 (Ja) (*Soil Sci. Plant Nutr.,* 1976, 22, 499).

Field research over a year was carried out to determine whether fertilizer contributed to deterioration of water quality of the Kasumigaura lake. The fates and balance sheets of N and P were investigated in the rice paddy fields with or without application of fertilizers. The nutrient concentrations in the surface water reached 63 ppm N and 26 ppm P in the paddy field with surface application of fertilizer. More or

less than 19.8 % N and 1.8 % P of fertilizers added to the field were lost by surface run-off water and vertical percolating water. The large loss of nutrients out of the field was due to surface run-off, while percolation loss of N was less than one third of it by surface run-off and the percolation loss of P was negligible. Ammonium form was the most likely N to be lost out of the field. The amount of nitrate lost from fertilizer applied field was rather little, which was almost the same as that from no fertilizer applied field. The method of application of fertilizer and the water management, especially in the short period after the application of fertilizer, were the most significant determinants to minimize the loss of fertilizer elements. 3759

TAKKAR, P. N. *et al.* — **Yield and uptake response of corn to Zn, as influenced by P fertilization.** *Agron. J.*, 1976, 68, 942-6 (En).

A field experiment was conducted for 3 years from 1970 to 1973 with a fixed wheat corn rotation to determine the effect of P and Zn fertilization on corn yield, uptake, and translocation of Zn, and to evaluate the parameters that would monitor best the P-Zn interaction in corn. Five rates of P and four rates of Zn were applied to P- and Zn-deficient soil (Ustipsamments) using a split-plot design. P was applied to all the six crops and Zn only to the first and second crops. Optimum response of corn to P was observed at 44 kg/ha P. The high P supply beyond the optimum P rate produced severe Zn-deficiency symptoms in treatments without added Zn and a significant decrease in grain and stover yields. This resulted from a significant decrease of Zn and a significant increase of P concentration in the shoots of the plant with a high P supply. An increase in the supply of Zn alleviated its deficiency symptoms, significantly increased Zn concentration and its uptake, and resulted in a significant increase in growth and yield. The requirement of Zn increased at high (66 to 88 kg/ha) rates of P fertilization. The main effect of P on Zn utilization by corn was to reduce the rate of Zn entry into the roots and induce deficiency. The P-Zn disorder was better related with P/Zn ratio in the soil and in different parts of the corn plant than either with the P or Zn content of the tissues and soil. Values of P/Zn greater than 7.5 in the soil, 245 in grain, 130 in stover, 150 in the leaves (of 25-day-old plants) indicated a severe Zn deficiency in corn and a highly significant response to its application. The P/Zn values 4 to 7.5 in the soil, 150 to 245 in the grain, 90 to 130 in the stover, and 100 to 150 in the leaves indicated moderate Zn deficiency or response to its application. (R) 3736

TIWARI, K. N. & PATHAK, A. N. — **Effect of P fertilization on Zn nutrition of rice crop in an alluvial soil of Uttar Pradesh.** *Indian J. Agric. Sci.*, 1976, 46, 269-73 (En).

Greenhouse studies were undertaken to study the effect of different levels of P on Zn nutrition of rice ('IR 49'). In general, an increase in the supply of P up to 200 ppm induced a growth disorder that could be alleviated by an increase in the supply of Zn. An increase in the supply of P or Zn also decreased the concentrations of the other nutrient. A mutual antagonism was observed in their concentrations and uptake by the crop. The critical concentration of Zn or P associated with Zn deficiency could not be assessed, but there was deficiency when the P : Zn concentration ratio was 301 in the shoot at panicle emergence, 543 in the grain and 104 in the straw at final harvest. (R) 3816

b. OIL, SUGAR AND FIBER PLANTS

BRAGA, J. M. *et al.* — **Response of the "Santa Rosa" soybean cultivar to P, K and lime application in latosols of the mine triangle. II. Correlation with soil chemical test.** *Rev. Ceres*, 1976, 23, 21-9 (Pt, en).

With data on soybean production obtained with applications of P at levels of 0, 100, 200 and 300 kg/ha P_2O_5 with and without lime, and of K at levels of 0, 50 and 100 kg/ha K_2O and results of chemical analyses of 17 latosols from the Triangulo Mineiro, correlations between soil plant parameters were determined in order to provide a better orientation for recommendations for fertilizing soybeans. The results allowed the conclusion that pH values and the sum of bases were positively related to soybean yield and to relative production according to P levels, but the opposite relationship was observed in respect to exchangeable Al. Correlation coefficients between available P and soybean and between available P and relative production according to P application levels were not significant. Available K, at the same time, correlated significantly and positively with soybean production and with response to the use of P, but the correlation between available K and relative production according to K application level was not significant. (R) 3504

COOMANS, P. & OCHS, R. — **Profitability of mineral fertilizers on coconut palms in South-Eastern Ivory Coast conditions.** *Oléagineux*, 1976, 31, 375-80 (Fr, en, es).

Amongst the production factors fertilization is certainly the one which brings the quickest yield increase on coconuts in South-Eastern Ivory Coast conditions. At current market prices an annual manuring consisting of 0.7 kg tricalcium phosphate, 2 kg KCl and 1 kg kieserite per tree procures a net profit of 70,000 CFA francs per ha/year; an extra annual investment of about 60,000 CFA francs leads to an increase of 130,000 CFA F in receipts, i. e. a return of 2.2. A study of the response curves for K, P and Mg confirms the validity of the critical levels for leaf analysis retained up to now in the management of mineral nutrition in an industrial plantation. (R) 3724

COOMANS, P. — **First experimental results on the fertilization of hybrid coconut in the Ivory Coast.** *Oléagineux*, 1977, 32, 164-6 (Fr, en, es).

Mineral nutrition experiments done at Port-Bouet on sandy soils with low mineral element content have shown that it is absolutely necessary to apply an N, K, Mg balanced fertilizer to a hybrid coconut palm from the time of planting. Fertilizers can be classified in the following descending order: potassium chloride, kieserite and urea. They have a very clear-cut effect on the vegetative development, precocity of flowering and on the first yields, which reach 3,400 kg copra in year n5 (from 4 1/2 to 5 1/2 years). The effect of the elements applied is directly related to their absorption. The results of the experiments have made it possible to establish a provisional manuring schedule for the Dwarf × Tall Port Bouet 121 hybrid coconut in the soil and climatic conditions of the South-East Ivory Coast. (R) 3773

DEAT, M. *et al.* — **Mineral exports of cotton plant and some tropical cultures of African savannahs.** *Cot. Fib. Trop.*, 1976, 31, 409-18 (Fr, en, es).

Traditionally, the estimation of the exports of mineral elements by crops is made from the yield of the useful part of the plants and export standards reduced to 1 000 kg/ha of harvested product.

Some results obtained by the IRCT in tropical Africa (Cameroon, Ivory Coast and Dahomey), demonstrate that this method of calculating exports gives rise to considerable errors in the context of the semi-intensive agricultural practices in African savannahs.

Thus, an investigation of the principal causes of variability revealed the strong influence exerted by ecological factors on:

a) the quantity of DM actually exported, and the ratio: harvested product/production apparatus;

b) the elementary composition of the different parts of the plant (in particular as regards N and K).

These observations have led to a method being proposed, which is both simple to use and sufficiently precise, for measuring mineral exports for each particular ecological situation.

A number of results obtained with cotton, sorghum and groundnuts are described, as also an example of the application to the calculation of approximate mineral balance sheets which, together with soil analyses and foliar diagnosis, provide a group of facts which are essential to the study of mineral fertilization and fertility maintenance in African cultivation systems. These results also draw attention to the considerable quantities of cations and N mobilized by the harvest residues which, as a matter of practice, should be ploughed back into the land to limit the degradation of soils and economize fertilizers. (R) 3800

HOHOLA, J. *et al.* — **Influence of mineral fertilizer on quality of sugar beet.** *8th Int. Fert. Congress, Moscow*, 1976, 6, 116-22 (Ru).

The paper summarises the results of over 200 field experiments conducted in the USSR, Hungary, Czechoslovakia and GDR during the last 15 years. The data from Czechoslovakia on diffusion sap composition of sugar-beet for the last 15 years demonstrate the effect of high rates of N fertilizers on N utilization by sugar-beet. Total N content during this period increased by 70 %. All the treatments showed negative effect of N fertilizers on sugar content. This was more negative in case of higher rates. Application of PK fertilizers in 198 comparable cases resulted in increase of sugar content from 18.0 to 18.2 % against control (no fertilizers). Irrigation resulted in increase of sugar content by 0.2 % in plots without fertilizers and by 0.4 % in plots with 80, 160 and 240 kg/ha N. 3628

KNECHT, J. C. X. *et al.* — **Variation of leaf nutrient contents with age of palms in oil palm leaf sampling.** *Oléagineux*, 1977, 32, 139-45 (En, fr, es).

The variations in the mineral element composition of frond 17 according to the age of the palms were studied in three plantations in Malaysia. The results of three years' samplings (1970-72) were taken as a basis. Significant linear correlations were obtained for N and K, which leads the authors to propose different critical levels in function of the age of the trees: from 2.78 to 2.30 % DM for N and from 1.32 to 0.82 % for K for an age ranging from 5 to 30 years. For Ca, a tendency to an increase in the leaf level was observed in two plantations, whereas in the third the trend was in the opposite direction, the level decreasing with age; further studies would therefore be necessary before any definite conclusions can be drawn. As regards P and Cl, no relationship between leaf levels and the age of the palms could be established. (R) 3772

RICHARD, L. — **Petiolar diagnosis of N nutrition of cotton plant.** *Cot. Fib. Trop.*, 1976, 31, 429-37 (Fr, en, es).

The reactions of the cotton plant to N fertilizations are very varied depending on the soil and climatic characteristics of tthe environment. N has a direct positive effect on growth, the development of the fructiferous organs and the earliness of flowering; on the other hand, the increase in size can cause production to be retarded. The interaction of the effects of N fertilization and the organic content of the soil is negative. This complex situation encourages the search for a simple test to follow the N stages during vegetation. The content of ws N of the petiole of the terminal leaf enables this stage to be characterized. A reference curve showing the optimum N content according to the age of the cotton plant is suggested; this curve is strongly influenced by the duration of the period which is favourable to the water stages of the plant. (R) 3801

TONKAL, E. A. — **Effect of mineral fertilizers on the sugar content and technological properties**

of sugar beet. *8th Int. Fert. Congress, Moscow,* 1976, 2, 65-70 (Ru).

An optimum N and P supply of beet influences protein synthesis positively, reduces excessive N, and improves some technological root features. The application of optimal doses of K stipulates substantial increase of sugar content in beet roots by 0,5-0,6 %. K fertilizers cause both the increase of good quality of cleaned normal juice and the decrease of soluble juice content. 3582

WOSHKERUSHA, J. — **Effect of mineral fertilizers on the quality of winter rape.** *8th Int. Fert. Congress, Moscow,* 5, 1976, 193-9 (Ru).

This report is a review of results of research carried out in the GDR, Poland and Czechoslovakia, on the effect of fertilization on winter rape quality.

Everywhere, independent of climatic and agrotechnical factors, high N rates decreased oil content and increased protein content. The increase of P and K doses (studied in Poland) did not give significant differences in oil content in winter rape seed. The effect of fertilizers on fatty acid content in winter rape oil was studied only on standard varieties with high erucic acid content. N fertilizers decreased the content of oleic, linoleic acids and increased erucic acid content. Similar effect is manifested by S. The effect of P on fatty acid content is favourable, the proportion of oleic and linoleic acid is increased while that of erucic acid is decreased. K fertilizers manifested no significant effect on fatty acid content. In microelements only B had a tendency to increase the content of such acids as oleic, linoleic and linolenic, and to decrease erucic acid content. 3622

c. GRASSLAND AND FODDER CROPS

AWAD, A. S. *et al.* — **Effect of pH and P on soluble soil Al and on growth and composition of Kikuyu grass.** *Plant & Soil,* 15, 531-42, 1976 (En).

Kikuyu (*Pennisetum clandestinum* Hochst) grew relatively poorly on the Wollongbar krasnozem at soil pH values below 4.36. At these low pH values DM yields were increased by raising the pH or by application of high rates of P. Both treatments decreased the concentration of soluble soil-Al on which the concentration of Al in tops was linearly dependent (r =0.95). The inverse relationship found between plant growth and Al concentration, when present in excess of ~ 1.5 μg/g soil and ~ 90μg/g tops, is suggestive of Al toxicity. However, at Al concentrations causing severe yield reductions, the Ca concentration in kikuyu tops was approaching deficiency levels. The Al-Ca antagonism was further demonstrated by the reduction in Ca-uptake caused by increased concentrations of soluble soil-Al under constant conditions of exchangeable Ca and of pH. The yield-reducing effects of Al toxicity *per se* and Al-induced Ca deficiency are therefore confounded. (R) 3666

DEMARQUILLY, C. — **Influence of fertilization on the feeding value of forage.** *Fourrages,* 1977, 69, 61-84. (Fr, en).

With the help of numerous bibliographic references from France and other countries, the author investigates the effect of mineral fertilization (N, P, K) of pure swards on the morphological and chemical composition of the forage, its nutritive value (digestibility of OM and energy content, digestibility of proteins and proteic value), the voluntary intake, and lastly the animal performances (grazed and stored herbage).

Fertilization has little or no effect on the feeding value of the forages under investigation, and is very beneficial insofar as it is possible to make good use of the increment in DM thus produced. In the case of N fertilization, the author underlines the great interest of modulating the applications so as to have a better distribution of the forage produced during the year. (R) 3834

FARODA, A. S. & TOMER, P. S. — **Nutrient uptake by fodder varieties of cowpea under P, N and bacterial fertilization.** *Forage Res.,* 1975, 1, 47-53 (En) (*Soils & Fert.,* 1977, 40, 1, No. 267).

3 cowpea cultivars were given 0, 17 or 34 kg/ha P_2O_5 and 0 or 20 kg/ha N and seed inoculation with a *Rhizobium* sp. The N contents and uptake of N, P, K and Ca in DM were the highest in cv. No. 10. The P contents were similar in the 3 cultivars, but K and Ca contents were higher in cv. EC 4216. The Ca:P ratio was lowest in cv. No. 10. Application of 17-34 kg/ha P_2O_5 increased N and P contents, and uptake of N, P, K and Ca, and decreased the Ca:P ratio, but had no effect on K and Ca contents. Application of N and seed inoculation had no significant effect on chemical composition. 3769

HALAND, A. — **P and K application on ley at high N level.** *Forskning Forsøk Landbruket,* 1976, 27, 6, 701-15 (No, on).

During the years 1970-74 18 field experiments concerning P and K application on ley were carried out in south western and southern Norway. Each experiment, which continued for three years in succession, was based on a high N level and connected to experiments dealing with the question of how much compound fertilizer (fullgjødsel F 16-3-15) should be used for each harvesting throughout the season. The results did not suggest any need of great changes in the composition of the compound fertilizer when the N rate is high. There was a distinct crop failure the first year without any P application. The failure, which became even more severe in the second and third years, was stronger and increased faster on sandy soil than on morainic soil, usually containing some clay. Simultaneously the P content in the soil decreased, and on all the soil types a dressing of approximately 68 kg/ha P yearly was necessary to maintain, over the three year period, the initial level which was on average P-AL 18. (R) 3668

McLEAN, E. O. & SSALI, H. — **Effects of P rate and form in combination with lime and gypsum on yields and compositions of German millet (*Setaria italica*) and alfalfa from highly weathered soils.** *Soil Sci.*, 1977, 123, 155-64 (En).

The study was conducted in a growth chamber on three relatively highly weathered soils, i.e., two Oxisols from Uganda and one oxidic Ultisol from Tennessee. German millet yields increased significantly when P was applied at all pH levels on all soils. On the relatively more weathered Kabanyolo and Alcoa soils, yields were not significantly different from P_1(TSP) and P_2(PARP), but those from P_2(TSP) were superior to both P_1(TSP) (37 kg/ha P) and P_2 (PARP) (74 kg/ha P). On relatively less weathered Serere soil, yields of German millet were not significantly different from P_1(TSP) and P_2(TSP), but both were significantly higher than that from P_2 (PARP). For all soils, German millet yields were highest at lowest pH level, and decreased with increasing pH. Alfalfa yields were significantly increased by P on Serere and Alcoa soils, but they were not significantly different from P_1(TSP), P_2(TSP) or P_2(PARP). In contrast, alfalfa yields were significantly depressed by P on Kabanyolo soil which had relatively high levels of Al-P and native available P. Alfalfa yields markedly increased with initial increase in pH and generally continued to increase at high Ca and pH levels. (R) 3731

LITTLE, D. A. & McLEAN, R. W. — **Prediction of the P content of herbage consumed by grazing cattle.** *J. Agric. Sci.*, 1977, 88, 533-8 (En)

The determination of feed P content using oesophageally fistulated cattle is reported in this paper, from an experiment in which salivary P was labelled with ^{32}P. The P content of consumed feed was calculated from the degree of reduction in salivary specific activity by the feed P, expressed as the ratio of the specific activities of bolus and saliva P. A dose of 100 μCi ^{32}P allowed the accurate prediction of P content ranging from 0.07 to 0.25 % in various feeds, at intervals from 3 to 24 h after the ^{32}P infusion; the predicted and actual P concentrations were highly correlated ($r = 0.95$). Similar observations for feeds ranging from 0.14 to 0.25 % P suggested that accurate prediction was also possible 144 h after infusion. Comparison of estimated feed P content of grazed material with that measured in hand-plucked herbage indicated that this approach is applicable to grazing studies. (R) 3819

LUDWICK, A. E. & RUMBURG, C. B. — **Grass hay production as influenced by N-P topdressing and by residual P.** *Agron. J.*, 1976, 68, 933-7 (En).

A 4-year experiment was conducted on a Fola cobbly sandy clay loam soil near Gunnison, Colorado. Vegetation consisted of a mixed stand of bromegrass (*Bromus inermis* Leyss.), timothy (*Phleum pratense* L.), orchardgrass (*Dactylis glomerata* L.), bluegrass (*Poa pratense* L.), and occasional plants of red clover (*Trifolium pratense* L.). Treatments were 4 rates of both N and P applied either in the fall or spring, prior to the first growing season. Residual P was evaluated the following three seasons. Hay yields the 1st year (1972) were significantly increased from 2.51 t/ha with no fertilizer to 10.77 for the highest fertilizer combination of 358 and 59 kg/ha N and P fall applied. Yields increased with increasing rates of both nutrients. Yields from fall applied N-P combinations averaged 1 to 2.5 t/ha greater than yields from similar treatments spring applied. Uptake of both N and P followed trends similar to yields. Yields in 1973 and 1974 were increased over the control (0-P) by the initial P treatments, although yields and P uptake declined each year. Time of initial fertilizer application (fall vs. spring) did not significantly affect yields nor P uptake beyond the first season. Although residual P continued to increase yields and P uptake in 1975 (significant over the control at the highest P rate), reapplying P significantly increased both over all residual P levels. Bicarbonate extractable soil P levels were markedly increased in the upper 2.5 cm of soil by P topdressing. There was no evidence of P movement below 5.0 cm. (R) 3735

MAMAROVA, L. K. — **Effect of mineral fertilizer on yield, quality of lucerne and nutrient balance in soil.** *8th Int. Fert. Congress, Moscow*, 1976, 5, 305-11 (Ru).

Field and laboratory experiments were carried out by the Institute of Forage of Bulgaria in 1966-1973 to investigate the complex effect of N, P, and K fertilizers on the alfalfa quality and the crop value and some agrochemical characteristics of the soils. N and K fertilizers did almost not influence the growth of alfalfa while P fertilizers had a considerable effect on the yield and P content. After 4 years of investigation the tendency for the total N and P content increase and the total K decrease was observed in the tillable layer of the soil, i.e., the positive balance of N and P and the negative one of K. 3624

OSMAN, A. *et al.* — **Growth of subterranean clover in a range soil as affected by microclimate and P availability. II. Laboratory and phytotron studies.** *Agron. J.*, 1977, 69, 26-9 (En).

Growth of subterranean clover seedlings on a soil known to be P-deficient was studied under controlled environment conditions representative of the winter growth period in California's Mediterranean climate annual rangeland. P treatments were approximately 0, 22, 45, 90, and 180 kg/ha. A P adsorption isotherm was determined for the Sobrante and Las Posas soils used. The P adsorption isotherm predicted a fixation capacity of ca 80 and 120 kg/ha at equilibrium solution values of 0.1 and 0.2 ppm P resp. Plant weights were significantly affected by P rates only at the 3.0 and 4.5 leaf stages. Total P per plant was a more consistent indicator of P availability

than was percent P. Shoot:root ratios, nodules per plant, and percent crude protein in shoot and root increased with P availability. Fertilizer application rates that provide a minimum soil-solution level of 0.2 ppm P are indicated for optimal subterranean clover growth during Mediterranean climate winter conditions. (R) 3740

PICHOT, J. P. & TRUONG BINH. — **Action of endomycorrhizae on the growth and P nutrition of *Agrostis* in pots and on isotopically exchangeable phosphorus in the soil (L value).** *Agron. Trop.*, 1976, 31, 375-8 (Fr, en, es).

A study has been carried out in pots on a non-sterilized acid organic ferrallitic soil into which fragments of fresh roots highly infested by endogones were introduced. This inoculation had a marked effect on the start of *Agrostis* growth and P uptake by the plant. The L value determination did not allow to show an effect of endomycorrhizae on the pool of the mobile phosphate ions in the soil or the solubilization of a rock phosphate. (R) 3798

RAGUSE, C. A. & EVANS, R. A. — **Growth of subterranean clover in a range soil as affected by microclimate and P availability. I. Field studies** *Agron. J.*, 1977, 69, 21-5 (En).

Ridge, furrow, north-facing, and south-facing microsites were established to create variations in light and temperature microenvironments in previously tilled soils of the Sobrante and Las Posas series. An additional microsite treatment, consisting of a simulated range drill seeding, with and without a litter cover, was made on adjacent untilled soil. P rates, applied as SSP, were 0, 40, 80 and 160 kg/ha P. Large diurnal temperature differences were associated with microsite treatments and were more pronounced for soil than for air. Percent P in shoot tissue generally reached highest values in January, indicating that plant growth was restricted more during winter than was P uptake. With warmer temperatures and higher light intensities in February, growth dilution resulted in a decrease in P percentage. Small modifications of microrelief significantly altered the microenvironment, especially soil temperature. Morphological development and plant weight responses were greatest on south-facing slopes and at the highest P level. Seed production was not influenced by P fertilization. (R) 3739

THIAGALINGAM, K. & BENOIT, A. — **Interaction of blast furnace slag, P forms and Ca on the growth of sorghum and resistance to a fungus disease caused by** *Monochaetia* sp. — *Malaysian Agr. J.*, 1975, 50, 2, 248-53 (En).

The effect of a local blast furnace slag, Ca and two P- forms on the growth of lettuce and sorghum were studied in a pot experiment. The response was different in both the crops studied. Growth of lettuce was mainly influenced by Ca than the slag, whereas with sorghum, the slag gave a better growth. There was not much difference in the response due to forms of P in the two crops; generally, non-ws P gave a higher yield than the ws P. The interaction of slag along with P gave a twofold increase in growth of sorghum but not in lettuce; whereas Ca alone or the interaction of Ca and P was better in lettuce than in sorghum. P and Ca were found to increase the incidence of a leaf spot disease of sorghum caused by a fungus *Monochaetia* sp. but the interaction with slag reduced considerably the incidence. It was observed that both increase in yield and resistance against *Monochaetia* is due to the Si content in the slag. 3671

WESOLOWSKI, P. **Effect of fertilizers on chemical composition of yield and mesofauna of peat meadow.** *8th Int. Fert. Congress, Moscow*, 1976, 5, 168-76.

The investigations of the different effect of two, three and four hay cuttings and three levels of mineral fertilizers on the crop value, its chemical composition and the soil mesofauna were carried out at the meadows of the West Primorie on the peatmarsh soils in 1968-73. The content of total protein, P and K in the plant DM was found to be the function of the hay-cuttings frequency and the rate of fertilizers. The highest content of total P_2O_5, K_2O and total protein was determined for plants from the plots with two hay-cuttings. The Na content in the plants increased with more cuttings and decreased considerably at the increased rates of fertilizers. The Cu content decreased with the increase of the fertilizer rate at three- four hay- cuttings, the Mn content on contrary showed a tendency to increase with the rate of fertilizers. The highest amount of the earth worms was determined for the non-fertilized meadow, the lowest for fertilized meadow. The amount of the earth worms increased at more frequent hay- cuttings. With 4 hay- cuttings and the highest rate of fertilizer (N 140, P_2O_5 160, K_2O 240 kg/ha) the earth worms were found in the soil, but there were none of them at two and three hay-cuttings. The similar picture was observed for the click beetle grubs (*Elateridae*). 3621

WINTER, W. H. *et al.* — **I. Botanical and chemical composition of the pastures.** *Austr. J. Exp. Agric. An. Husb.*, 1977, 17, 66-74 (En).

The seasonal changes in the yield, botanical composition and chemical composition (N, P and S) of the pasture plants were measured in a grazing experiment over three years. The 48 treatments were factorial combinations of two different grasses with a common legume mixture, three annual maintenance rates of P fertilizer, four stocking rates of continuous grazing and two rates of P fed directly to the cattle. The pastures consisted of *Brachiaria decumbens* or *Panicum maximum* (common guinea grass) sown with *Stylosanthes guyanensis* and *Macroptilium atropurpureum*. *Brachiaria decumbens* was more persistent than *P. maximum* when heavily stocked at low fertilizer P rates and in the latter half of each wet season the legume content of the *Brachiaria* pastures

was lower. Of the two grasses, *P. maximum* contained the higher N, P and S contents. In the third year 20 kg/ha P gave higher yields than 10 kg/ha without affecting the chemical or botanical composition of the pastures, but 40 kg/ha decreased the legume content of the pastures and raised the P levels in stylo. Pasture yield decreased with increasing stocking rate with only minor effects on the botanical composition of the pastures. However, there was a concomitant increase in pasture quality, particularly in P content, with increasing stocking rate. (R) 3777

d. FOREST SPECIES

CLEMENT, A. & JANIN, G. — **Comparative study of the distribution of the main cations and of P in a poplar trunk.** *Plant & Soil*, 1976, 45, 543-54 (Fr, en).

This work gives the concentrations of mineral ions in each annual shoot and each annual ring of a 15-year old *Populus 'Fritzi-Pauley'* stem. When compared with previous results the new ones show:

— That P is distributed according to a pattern of 5 isodose zones (top-wood, peripheric-wood, sapwood, heartwood and central ring) which can be applied to mineral cations in the stem.

— That an opposition exists between P and cations (Ca, K, Mg, Zn, Mn) movements through a 'border ring'. On the inner side of this 'border ring' is heartwood with a lower P content than that of sapwood on the outer side of this ring. On the opposite, cations are more concentrated in heartwood than in sapwood. Part of this cation accumulation (mainly Ca) exists as $CaCO_3$. These ionic movements go with duraminisation. In the case of our $n = 15$ years old tree, duraminisation occurs in a n-5 year old annual ring.

— That in the functional parts of the tree K and P movements and at a lower degree Mg movement are quite alike and dependent upon mineral nutrition.

— That from a more practical point of view, the big differencies in ion concentrations in different parts of the stem make sampling difficult: a single disc of wood ground to sawdust cannot be representative of the composition of the whole stem. 3667

e. VEGETABLE AND FRUIT CROPS

BLATT, C. R. — **P and B interaction on growth of strawberries.** *Hort. Sci.*, 1976, 11, 597-9 (En) (*T.V.A. Fert. Abst.*, 1977, 10, 5, No. 1032).

Three cultivars of strawberry (*Fragaria x ananassa* Duch. cultivars Redcoat, Midway, and K68-108) were grown in sand culture and supplied with four levels of B interacted with three levels of P. Leaf B values of 2-5 ppm were associated with B deficiency symptoms in 'Redcoat' and K68-108. Maximum vegetative growth was obtained when leaf B ranged from 58-116 ppm for 'Redcoat' and K68-108 and from 14-33 ppm for 'Midway'. Leaf P and B were increased when P and B levels in the nutrient treatments increased, however there were no significant leaf P-B interactions exhibited. Leaf Ca increased and leaf K decreased as each cultivar approached maximum growth. Leaf B values for 'Redcoat' and K68-108 that were associated with maximum growth were similar to those associated with maximum growth in rutabagas. sugar beets, barley, and several forages. 'Midway' was found to be very sensitive to B additions. 3825

Bean production systems: highlights in 1975. *Ann. Rep.* 1975, *Centro Intern. Agric. Trop., Cali, Colombia*, C-45-C-49 (En).

The response of beans to P was studied in the extremely P-deficient volcanic ash soil of Popayan. Using TSP, highest yields were obtained with 300 kg/ha P_2O_5. With less soluble sources such as basic slag, RP and RP 20 % acidulated with sulphuric acid, beans responded to up to 400 kg/ha P_2O_5. Basic slag was the most effective source when all sources were broadcast and incorporated. Band placement of TSP would probably have improved its efficiency. RP from Huila was the least effective source, but at high rates it was definitely beneficial and economical. The partial acidulation of RP increased its efficiency to that of TSP.

Two additional sources, fused magnesium phosphate (MgP) and RP plus S were studied. Yields with fused MgP were not significantly different from those with TSP, and RP + S mixture was not much different from RP alone. A correlation between bean yield and % P in the upper leaves at time of flowering showed a critical P content in the leaves of 0.35 %.

The effect of N and P fertilization on yield and protein quality of three bean varieties was studied in four locations during two semesters. In the high OM, volcanic ash soil of Popayàn beans responded principally to P and only when the P-need was satisfied was there a clear response to N. In the highly infertile oxisols of Carimagua beans responded principally to N, and only when the N-need was satisfied was there a response to P. In the volcanic ash-influenced soil of La Zarata, with intermediate organic matter and low P content, beans responded equally well to N and P. 3510

EIRA, P. A. DA *et al.* — **P and K fertilizers for black beans, and their residual effects.** *Pesq. Agropec. Brasil. Agron.*, 1974, 9, 121-4 (Pt, en) (*Soils & Fert.*, 1977, 40, 1, No. 273).

In a field experiment, on an alluvial soil, yield of black beans was increased by application of P. Highest yield was obtained with 79 kg/ha P_2O_5, but most economic results were obtained with 55 kg/ha P_2O_5. Response to K was not significant but yields tended to decrease with increasing rates. The residual effect of both fertilizers was studied during the subsequent rainy season, when no effects for P and a linear response to K were observed. 3770

GREWAL, J. S. & SINGH, S. N. — **Critical levels of available P for potato in alluvial soils.** *Indian J. Agric. Sci.*, 1976, 46, 580-4 (En).

Field experiments were conducted on the alluvial soils of Jullundur to study the response of potato to P application and its relationship with the available P content of soils. The quantitative response was more in the autumn crop but the percentage response was higher in the spring crop. The available P content of these soils had a highly significant quadratic relationship with yield (%) of the autumn crop and linear relationship with yield (%) of the spring crop. An economic response to P application could be expected if the available P co ent of these soils is less than 20 and 26 kg/ha P for the autumn and spring crops resp. (R) 3712

SZÜCS, E. — **Fffect of subsoil fertilization on the nutrient content of soil and leavçs of fruit trees,** *8th Int. Fert. Congress, Moscow,* 1976, 4, 226-32 (Ru).

From the three most common ways of fertilization applied in fruit growing the effect of fertilizers, placed in lines into the subsoil, was studied.

The main conclusions are the following:

1. P diffuses to short distance from the fertiliser. After three years the soluble P content increased only in the 5 cm zone even in the case of the dose of 72 g/m P_2O_5.

2. The enrichment of soil P had no effect on the P_2O_5-content of leaves of fruit trees. 3609

UZO, J. O. — **Response of tomato to applications of P in an acid ferrallitic sandy loam soil under a humid tropical climate.** *Hortic. Res.,* 1976, 15, 53-62 (En) (*T.V.A. Fert. Abst.,* 1977, 10, 6, No. 1267).

Tomato utilization of P applied by three methods was determined by seedling height, % leaf P content at peak vegetative development, and fruit yield. Plants were more efficient in utilizing P presented in bands on both sides of the row than P applied either broadcast or by placement below the seedling row. The banding method of application reduces the contact between phosphate pellets and the soil but at the same time increases the amount of the applied P in contact with crop roots. It proved to be the most economic method of P fertilization. A higher rate of application than that currently recommended for the soil type employed in the study was necessary to maximize yields. This is because, in order to achieve a substantial response to P, sufficient P must be applied to satisfy all fixation sites and also meet fully the plant requirement for the nutrient. % leaf P content at the peak vegetative phase was a positive function of both the rate of P application and the method of application. 3828

f. STIMULANTS

BOUCHARD, L. & DAMOUR, M. — **Edaphic requirements of tobacco grown after water subsidence on alluvial soils in the Centre-West and North-West of Madagascar.** *Agron. Trop.,* 1976, 31, 232-44 (Fr, en, es).

The "baibos" lands consist of alluvial deposits brought by the river flood waters in winter.

Water is supplied to tobacco by the capillary fringe above the water table, its depth depends on the texture (homogeneity, fineness) and therefore on morphogenesis.

The physical and chemical characteristics of the soils have been studied. They showed that water retention, even when textures are rather coarse (less than 20 % of clay), was sufficient for tobacco; available N and B deficiencies could occur; available P content was poor; locally a slight salinity due to groundwater facilitated chloride uptake by tobacco and water excess at the beginning of the crop delayed the uptake of the ammonium ion resulting in longer growth duration. (R) 3797

COFFEE BOARD RESEARCH DEPARTMENT. — **28th Annual Detailed Technical Studies on foliar sprays of urea and SP on coffee. Report 1974-75. — Karnataka- India:** *Central Coffee Res. Inst.,* 1975, 172 p. (En).

An exploratory trial was carried out to determine i) the optimum concentration of urea and ii) the suitability of SP for foliar sprays. Urea was sprayed at concentrations of 1, 2, 5 and 10 % while SP with and without borax was sprayed at concentrations of 0.5 and 1.0 %.

The study indicates that urea can be sprayed at higher concentrations (o. up to 5 %) than that recommended at present (1 %) so that a considerable portion of the total N requirement can be met by foliar feeding. It also indicates the suitability of SP for foliar sprays. 3509

ROSAND, P. C. *et al.* — **Response of cacao to fertilizers in Southern Bahian soils.** *Boletim Tecnico* No. 43, 1976, 5-24 (Pt, en).

The influence of fertilizers on the yield of shaded and unshaded cocoa trees in several commercial areas of Bahia was determined. Yield calculated as the dry weight of cocoa beans was determined over a period of 10 years. The following results were obtained: Unshaded with Fertilizers (1,680 kg/ha) > Unshaded with no Fertilizers (1,258 kg/ha) > Shaded with Fertilizers (1,064 kg/ha) > Shaded with no Fertilizers (908 kg/ha). Non-fertilized unshaded cocoa trees in particular present a less dense canopy with several dry skeletorized branch tips. Chemical analyses of soil from the experimental areas were also made. Five levels of N, P and K in various combinations were tested using Catongo variety grown in different soil conditions. Results covering a period of 1971-74 showed a highly significant increase in production related mainly to applied P. The beneficial effects of N could be detected only in 1971 and 1972. No effect could be detected for K in any year. The paper also includes a discussion on the evolution of the fertilizer programme over the last 9 years and its influence on production and net profits. (R) 3818

VII

AGRICULTURE, FERTILISERS AND ENVIRONMENT

BAHNICK, D. A. — **The contribution of red clay erosion to orthophosphate loadings into Southwestern Lake Superior.** *J. Environ. Qual.*, 1977, 6, 217-22 (En).

The effects of the erosion of red clay deposits along the north-western Wisconsin shoreline area on orthophosphate inputs into Lake Superior was investigated. Using clay soil and river particulate samples, the release of orthophosphate in Lake Superior water was studied. The results indicate a maximum release of 240 t of soluble PO_4 from soil entering Lake Superior annually from shoreline erosion and 63 t of PO_4 from river particulates. These estimates assume equilibrium with soluble orthophosphate at a concentration of > 0.005 mg/l of PO_4, which is typical of Lake Superior water. Actual PO_4 release may be less because soluble PO_4 concentrations are higher in near shore waters. Suspended particulates buffer soluble PO_4 concentrations and may even cause a net removal of PO_4 from Lake Superior water when high concentrations exist. (R) 3794

BEEK, J. *et al.* — **P in soils treated with sewage water: I. General information on sewage farm, soil, and treatment results.** *J. Environ. Qual.*, 1977, 6, 4-7 (En).

A sewage farm which has been used during the past 50 years for treatment of raw sewage water of domestic and industrial origin was studied. The farm (100 ha) is situated on sandy soil and is in agricultural use as permanent pasture. Intermittent flooding of the soil with sewage water results in a 98% decrease of the biochemical oxygen demand (BOD) by passing it through the soil; phosphates are removed to the extent of 96%. These phosphates accumulate in the top 50-cm layer of the soil. Removal of N compounds is less effective. The sewage water additions raised the pH of the soil and increased the OM content (mainly of the top layers). (R) 3716

BEEK, J. *et al.* — **P in soils treated with sewage water: II. Fractionation of accumulated phosphates.** *J. Environ. Qual.*, 1977, 6, 7-12 (En).

Surface flooding of a sandy soil with raw domestic sewage water induced an accumulation of P in the top 50-cm layers. Three different soil P fractionation methods described in litterature have been applied to samples of different soil layers. Two soil treatments were involved, viz., 30 and 59 years sewage water flooding. Accumulated phosphates mainly consisted of inorganic phosphate forms (80 to 85%). These inorganic phosphates are constituted particularly of Al-bound phosphates; thus, indicating the dominant role of Al-related reactions in the phosphate-bonding mechanism in this case. (R) 3717

CHICHESTER, F. W. — **The impact of fertilizer use and crop management on N content of subsurface water draining from upland agricultural watersheds.** *J. Environ. Qual.*, 1976, 5, 413-6 (En).

Spring flow and stream base flow sites were sampled weekly on and adjacent to a 123 ha agricultural watershed in the Allegheny-Cumberland Plateau physiographic region of east-central Ohio. Measured N contents of spring flow were related to fertilizer N regime of the different agricultural practices investigated. Changes in land management on the area contributing to spring flow were reflected in changes in N content of water from that spring. The amount of N transported into the stream channel was directly related to seasonal variation in sub-surface flow rate in two ways. First, the concentration of N in spring flow increased with an increase in the amount of water percolating through the overlying soil and shale. Second, the extent to which downstream quality was affected, i.e., the distance from the area of fertilizer application at which an increase in N content could be detected, also increased with the volume of flow from the springs. (R) 3721

MATTINGLY, G. E. G. — **Leaching and movement of nutrients in soil.** *Rothamsted Exp. St. Rep.*, 1976, 1, 87-8 (En).

Modelling solute leaching in structured soils. A computer model has been developed in which the soil (at field capacity) is treated in layers. As a working approximation, soil pores are divided into two categories, (i) those in which solute and water move in piston flow each time rain falls, and (ii) those in which they are retained in the layer. The amount of water held by each category is defined with reference to the soil moisture characteristic. Equalisation of solute concentration between categories (i) and (ii) is assumed to occur after each rainfall 'event', and gives 'hold-back' of solute for subsequent release. The model permits solute and water to move through the large pores of an indefinite number of layers during heavy rain. It predicts the amount of solute in each layer of a profile after any number of rainfall or evaporation 'events', and can either store water and solute in the bottom layer for withdrawal up the profile when evaporation occurs, or subtract any previous evaporation from rainfall and predict the solute concentration in each aliquot of drainage from the bottom layer. 3831

RIEMSDIJK, W. H. VAN *et al.* — **P in soils treated with sewage water: III. Kinetic studies on the reaction of P with Al compounds.** *J. Environ. Qual.*, 1977, 6, 26-9 (En).

The reaction of P with $Al(OH)_3$ and αAl_2O_3 was studied at an initial PO_4 concentration level of 0.35 mmoles/l and a temperature of 20C. Solutions of KH_2PO_4 and synthetic inorganic sewage water were used as P sources. In all experiments involved, a marked change of the reaction rate was found after about 1 day in the case of $Al(OH)_3$ and about 4 days in the case of αAl_2O_3. This can be explained by the

assumption that at these points the formation of a solid Al phosphate is initiated. This new phase was later identified as Sterrettite by means of electron microscopy, electron diffraction, and X-ray diffraction. (R) 3718

SHARPLEY, A. N. & SYERS, J. K. — **P transport in surface run-off as influenced by fertilizer and grazing cattle.** *N.Z.J. Sci.*, 1976, 19, 277-82 (En) (*T.V.A. Fert. Abst.*, 1977, 10, 6, No. 1269).

The effects of fertilizer and grazing cattle on the transport of P in surface run-off were evaluated using field plots and natural rainfall. During 4 months, the proportions of forms of P lost in surface run-off from one fertilizer application (50 kg/ha P) to a 13° undrained slope amounted to 2.9, 3.2 and 6.7 % as dissolved inorganic P (DIP), total dissolved P (TDP), and total P (TP), respectively. Slightly lower amounts of fertilizer P were lost from a 6° undrained slope, and a much lower proportion was lost from a 6° drained slope (0.60, 0.70 and 1.00 % as DIP, TDP and TP, respectively). This may be attributed to a 4-fold reduction in the vol of surface run-off and to the lower mean dissolved and particulate P concentrations in surface run-off from the drained plot. Losses of P resulting from one grazing by dairy cattle amounted to 0.16, 0,46, and 0.77 kg/ha P as DIP, TDP and TP, respectively, in the ensuing 4 weeks. The forms of P in run-off which were most affected by grazing animals were dissolved organic P (DPO) and total particulate P (TPP). Fertilizer application had a more sustained effect on DIP and TPP losses than grazing animals. Forty days after fertilizer application, the loss of DIP was only twice that from the control, whereas that of TPP was 5 times greater than that from the control. The sustained effect of fertilizer addition on the transport of TPP is discussed along with the relative importance of fertilizer and grazing cattle in the transport of P forms in surface run-off. 3829

SIEGEL, R. S. *et al.* — **P fertilizer as a by-product of energy production from agricultural wastes.** *J. Environ. Qual.*, 1977, 6, 116-20 (En).

Three pot experiments were conducted to test the utilization of ash from different kinds of animal manures and vegetative crop residues as source of P fertilizer. Corn yield grown on P-deficient soil (Aiken loam), treated with acidified ash at rates equivalent to 200, 400, 800 and 1,200 ppm P, responded almost like CSP at the same rates. Yields from pots treated with ash acidified at 50 % of its base equivalent were slightly less than those at 100 % acidification. The leached acidified ash of agricultural waste materials proved to be a comparable source to CSP fertilizer. (R) 3790

SINGH, B. & SEKHON, G. S. — **Impact of fertilizer use on environmental pollution in Punjab: present status and future projections.** *Fert. News India*, 1977, 22, 3, 7-11 (En).

This paper summarises the situation in the Punjab, where fertilizer application rates are the highest in India, the area is largely irrigated, soils are intensively cultivated and are light in texture. Fate of pollutant components of fertilisers in the soil is discussed in relation to nitrate pollution of ground water and heavy metal contamination of the soil. Some measures which do not require additional investment for their implementation have been described for minimising nitrate pollution of ground water, if any. Projections and research needs have also been discussed. (R) 3711

WIERER, K. — **The organization and development of fertilizer marketing in developing countries.** *Z. Ausländ. Landw.*, 1976, 15, 288-304 (De, en) (*Abst. Trop. Agric.*, 1977, 3, 4, No. 13816).

This paper shows that developing countries increasingly use fertilizers to increase agricultural production although there are large differences in fertilizer use according to regions or crops. Factors that influence fertilizer consumption are analyzed with special attention to the fertilizer marketing organizations and to the integration of fertilizer marketing with agricultural extension, credit organization and agricultural produce marketing. Although a determined marketing system is based on a certain economic policy orientation, it is emphasized that the system must be adjusted to the stage of development and structural changes are needed from time to time. (R) 3808

WILDUNG, R. E. *et al.* — **The P status of eutrophic lake sediments as related to changes in limnological conditions — P mineral components.** *J. Environ. Qual.*, 1977, 6, 100-4 (En).

The present studies were undertaken to identify the inorganic P components responsible for the changes in sediment inorganic P using chemical techniques for characterization of P where changes occurred. Release of P from sediments during periods of maximal biological productivity in the shallow bay waters was due primarily to reductions in inorganic P mineral components soluble in NaOH 0.1*M* and citrate-dithionite, suggesting that P associated with hydrated Fe oxides was the principal source of P to the overlying waters and to the biota. Increases in sediment inorganic P, which occurred when phytoplankton growth diminished, were due principally to increases in P mineral components soluble in NH_4F, indicating that resorbed P was F-exchangeable and/or associated with crystalline and amorphous Al-P components. Changes in the form of sediment P which occurred in the lake and in laboratory equilibrium studies, indicated that conversion of resorbed NH_4F soluble-P to NaOH 0.1*M* and citrate-dithionite soluble-P, must be a relatively long term (> 2 years) process. Taken together, the NH_4F, NaOH 0.1*M*, and citrate-dithionite fractions accounted for approximately 85 % of the seasonal variance in total inorganic P which occurred at all sampling locations in the lake system. (R) 3713

ZADE, K. B. & KAMAT, V. N. — **Studies in losses of N by volatilization from deep black soil fertilized with N fertilizers separately and in combination with SP.** *Punjab Krishi Vidyap. Res. J.*, 1975, 3, 121-5 (En) (*Soils & Fert.*, 1977, 40, 4, No. 1887).

In a pot experiment, higher losses of N by volatilization from soil were recorded with urea than with AS (20 and 16 %, resp. after 110 days). Addition of SP reduced the losses by 60 to 80 %. When wheat was sown in the pots, losses after 110 days were only 10.5 and 9.3 % for urea and AS respectively; addition of SP reduced the losses to 2 to 3 %. 3750

NEW BOOKS AND PUBLICATIONS

BROWNLIE, I. A., DAVIDSON, E. & DICK, T. R. — **Developments in ammonium phosphate technology.** *Fert. Soc. London*, 1977, 162, 52 p. (En). 3700

UEXKULL, H. R. von — **Aspects of fertiliser use in modern, high-yield rice culture.** *Intern. Potash Inst.*, 1976, (*IPI-Bull.* 3), 74 p. (En). 3701

JURGENS GSCHWIND, S. & JUNG, J. — **Ergebnisse von Lysimeter-Untersuchungen in der Grossanlage Limburgerhof** (Die wichtigsten Befunde aus 50 jahren Versuchstätigkeit, 1927 bis 1977). — (Results of lysimeters research at Limburgerhof research station. — The most important findings in 50 years of research work). — Limburgerhof (6703): Landwirtschaftliche Versuchsstation der BASF AG, 1977, 177 p. (De). 3702

PRASAD, R. & DIXIT, L. A. — **Fertilizers containing partially water-soluble or not water-soluble phosphate.** — *New Delhi: Indian Council Agricultural Research*, 1976, 34 p. (En). 3703

INTERN. POTASH INST. 10th Congress, 1974, Budapest, Hungary. — **Potassium research and agricultural production.** *Reprints of the papers presented during the Working Sessions of the Congress*, 284 p. (En, fr, de). 3704

FAI/ISMA Seminar, 1975, New Delhi. — **Proceedings of the Seminar on technology of compound based on urea, and use and beneficiation of low grade phosphate rock.** New Delhi: *Fert. Assoc. India.* 1976 (En). 3705

2.000 Abstracts on Cassava (*Manihot esculenta* Crantz). — *Cali (Colombia): Library and Information Services Program CIAT*, 1975, 584 p. (Series HE-26; vol. I) (En). 3706

Abstracts on field beans (*Phaseolus vulgaris* L). — *Cali (Colombia): Bean Information Center CIAT*, 1976, 494 p. (Series HE-29; vol. I) (En). 3707

ADVANCES IN AGRONOMY, *edited by N. C. Brady, New York, San Francisco, London: Academic Press*, 1976, XII, 411 p. vol. 28. This publication includes the following chapters: Nitrogen stress in plants. — Statistical methods in soil classification research. — Nitrate accumulation in vegetables. — The progress, problems, and prospects of plant protoplast research. — Crop water deficits. — Use of tracers for soil and fertilizer nitrogen research. — Nucleo-cytoplasmic relationships in wheat. — Aspects of the comparative physiology of grain yield in cereals. — The biological yield and harvest index of cereals as agronomic and plant breeding criteria. (En). 3708

The fertility of paddy soils and fertilizer applications for rice. *Food & Fertilizer Technology Center for the Asian and Pacific region.* Tapei (Taiwan, Republic of China): 249 p. (En). 3709

Very long-term fertilizer experiments. Intern. Conf., Grignon, July 1976, *Ann. Agron.*, 1976, 27, 5-6, Special Number, 1095 p. (Fr, en).

Thirty papers, plus discussion, dealing with general and special aspects of very long term fertiliser experiments concerning crop rotations, monoculture and grassland in various parts of the world.

This volume is available at the Service des Publications de l'Institut National de la Recherche Agronomique, Route de Saint-Cyr, 78000 Versailles, France (Price: F. 135).

PHOSPHORUS IN AGRICULTURE

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