Chemical Effects of a Soil Conditioner upon Plant Composition and Uptake

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Chemical effects of a representative sodium polymer soil conditioner upon plant composition were determined through 760 analyses of greenhouse crops from eight soils, unlimed and limestoned. In one experiment, the soil conditioner was incorporated at rates of 0.02, 0.05, and 0.10% in upper and full-depth placements in triplicate in Clarksville silt loam. In most cases the two larger inputs of conditioner caused significant decreases in the calcium and magnesium contents of the four successive crops, and substantial increases in potassium and sodium contents. Largest recovery of sodium per crop per acre was 50.6 pounds, and maximal recovery was 65 pounds, or 25% of the input. The conditioner did not register positively upon the growth and phosphorus pentoxide content of the four successive crops. In another experiment, the conditioner was incorporated at the rate of 0.05% in seven silt loams, one series unlimed and one limestoned before four previous crops, and red clover and millet were grown in succession after incorporation of the conditioner. The seven soils of both series registered significant differences in growth and nutrient contents of crops. In general, addition of the soil conditioner caused decreases in the calcium and magnesium contents and uptake with increases in the potassium and sodium uptake.

Small percentage incorporations of synthetic organic polymers have been found to bring about decided improvement in the physical properties of soils (*1, 3, 4, 6–13, 16, 17*). Such improvement should induce beneficial biochemical activities, with resultant increase in vegetation of superior nutrient value. However, the papers on soil conditioners have dealt almost entirely with the effects of polyelectrolytes upon soil structure and plant response. The primary objective of the two experiments reported here was to ascertain whether incorporations of a water-soluble polymer (hydrolyzed polyacrylonitrile) would induce ionic exchanges in soil systems and cause differential cation migrations into the above-ground growth of a succession of crops on selected soils, unlimed and limestoned.

The material used was furnished by the Monsanto Chemical Co. and was designated as a resin to function as "a synthetic replacement for the natural polysaccharide or polyuronide resins derived from humus." It contained 13.2% of sodium and its ash comprised 36% sodium carbonate.

Experiment I

Red clover, millet, red clover, and rye grass were grown in that order on 42 pot cultures of 8-inch depth on Clarksville silt loam. That soil had an initial pH of 5.6 and an exchange capacity of 6.9 meq., accounted for by 1.74 meq. for calcium, 0.48 meq. for magnesium, 0.08 meq. for potassium, and 4.60 meq. for hydrogen per 100 grams of soil.

The bulk of soil was processed and potted as previously described (*7*). Half of it was limestoned at the rate of 2 tons per 2,000,000 pounds of soil to impart a final pH value of 6.5. The triplicated cultures were fortified through upper-zone incorporations of concentrated superphosphate and potassium sulfate that supplied phosphorus pentoxide and potassium oxide at rates of 80 and 50 pounds per acre. The inputs of the conditioner are detailed in Tables I to IV. The quantity of conditioner required for each set of three pots was mixed into a dry fraction of the soil, and that fraction then was dispersed throughout the entire three-pot quantity of the soil whose moisture content of 10% was ideal for the dust-free inmixing of the dry fraction. A 100-cc. portion of the processed soil then was removed from each pot and the seeds were distributed evenly over the soil surface and covered through return of the 100-cc. portion of soil. The seeded soil then was wetted to 50% of its water-holding capacity. Top dressings of ammonium nitrate were applied to the millet of Table II and to the rye grass of Table IV.

After the seeding to obtain the second stand of clover (crop 3, Table III) all pots received second additions of phosphorus pentoxide and potassium oxide through surface application of a solution of potassium dihydrogen phosphate. The harvested plants were weighed, ground, and analyzed for contents of phosphorus pentoxide (*14*), calcium (*2*), potassium (*5*), and magnesium (*15*), by means of the cited procedures; the sodium values were determined through use of a Beckman spectrophotometer, Model DU, with flame attachment.

Results

Plant Response within each group and in general, did not register decided effects from incorporations of the polymer at three rates at half and full depths of placement, either alone or with limestone.

Phosphorus contents and uptakes from the untreated and treated soils were relatively uniform for the four crops of Tables I to IV. Significance for increase in phosphorus pentoxide values is indicated only for the 0.1% inputs of the polymer in the two series of Table V, in which the means of the aggregates were for both the unlimed and limestoned soils.

Calcium content of the initial crop of clover on Clarksville silt loam was lessened percentage wise, as was related uptake, by the 0.05 and 0.1% incorporations for both upper and full-depth placements on the unlimed and limestoned cultures. A repressive effect upon calcium content of the millet (crop 2) from the limestoned soil was registered only by the 0.1% input of the polymer. The

Table I. Red Clover Response and Composition (Crop 1) as Influenced by Incorporations of Conditioner[a]

Conditioner		Dry	P_2O_5		Calcium		Magnesium		Potassium		Sodium	
Input, %	*Placement in soil*	*Weight, G.*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Uptake, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*
					Clarksville Silt Loam, Unlimed							
None	...	7.0	0.45	7.8	1.35	23.7	0.43	7.5	2.43	42.5	0.045	0.8
0.02	Upper half	7.0	0.43	7.6	1.35	23.8	0.43	7.7	2.38	42.0	0.058	1.0
0.05	Upper half	7.0	0.43	7.5	1.31	23.1	0.44	7.7	2.56	44.7	0.074	1.3
0.10	Upper half	7.0	0.41	7.3	1.17	20.7	0.43	7.5	2.55	45.0	0.176	3.1
0.02	Full depth	7.2	0.43	7.8	1.31	23.7	0.43	7.7	2.45	44.3	0.056	1.0
0.05	Full depth	6.5	0.42	6.9	1.19	19.5	0.41	6.7	2.76	45.2	0.106	1.8
0.10	Full depth	6.7	0.42	7.0	1.16	19.6	0.41	6.9	2.72	46.0	0.223	3.8
					Clarksville Silt Loam[b], Limestoned							
None	...	8.0	0.47	9.6	1.83	36.9	0.39	7.8	2.48	49.7	0.046	0.9
0.02	Upper half	8.8	0.46	10.2	1.85	40.8	0.37	8.1	2.39	53.3	0.048	1.1
0.05	Upper half	8.1	0.45	9.2	1.75	25.5	0.35	7.1	2.64	56.0	0.060	1.2
0.10	Upper half	8.0	0.47	9.4	1.66	33.3	0.33	6.7	2.92	58.7	0.081	1.6
0.02	Full depth	8.4	0.48	10.1	1.72	36.2	0.34	7.2	2.82	59.2	0.043	0.9
0.05	Full depth	7.5	0.48	9.0	1.72	32.2	0.33	6.2	3.24	60.9	0.057	1.1
0.10	Full depth	7.3	0.45	8.3	1.57	28.8	0.35	6.4	3.22	58.7	0.080	1.4

[a] All pots fortified through inputs of 80 lb. of P_2O_5 per acre, as concentrated superphosphate, and 50 lb. of K_2O as K_2SO_4, in upper half of soil.
[b] Two tons, full depth, per 2,000,000 lb. of soil.

Table II. Millet Response and Composition (Crop 2)[a] as Influenced by Incorporations of Conditioner

Conditioner		Dry	P_2O_5		Calcium		Magnesium		Potassium		Sodium	
Input %	*Placement in soil*	*Weight, G.*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*
					Clarksville Silt Loam, Unlimed							
None	...	8.5	0.40	8.5	0.82	17.5	0.90	17.2	2.64	56.4	0.039	0.8
0.02	Upper half	9.0	0.40	9.2	0.83	18.7	0.85	19.2	2.57	61.7	0.046	1.1
0.05	Upper half	8.9	0.41	9.2	0.85	18.9	0.85	18.9	2.79	62.3	0.064	1.4
0.10	Upper half	9.4	0.36	8.4	0.81	19.0	0.81	18.9	2.65	62.1	0.111	2.6
0.02	Full depth	9.0	0.41	9.2	0.78	17.6	0.86	19.5	2.67	59.3	0.054	1.2
0.05	Full depth	9.3	0.41	9.5	0.79	15.1	0.78	18.0	2.70	62.8	0.121	2.8
0.10	Full depth	9.3	0.40	9.4	0.82	19.2	0.75	17.4	2.64	60.9	0.343	8.0
					Clarksville Silt Loam[b], Limestoned							
None	...	7.1	0.37	6.5	1.17	20.8	1.06	19.0	2.66	47.3	0.043	0.8
0.02	Upper half	7.8	0.38	7.4	1.20	23.2	1.00	19.3	2.75	57.9	0.045	0.9
0.05	Upper half	6.6	0.39	6.5	1.17	19.5	0.92	15.3	3.26	54.0	0.054	0.9
0.10	Upper half	7.0	0.41	7.2	1.20	20.9	0.92	16.1	3.19	55.8	0.084	1.5
0.02	Full depth	7.3	0.38	6.9	1.13	20.7	0.97	17.9	2.88	52.4	0.049	0.9
0.05	Full depth	6.9	0.38	6.6	1.16	20.1	0.90	15.8	3.38	57.5	0.053	0.9
0.10	Full depth	6.3	0.38	5.8	1.04	16.3	0.81	12.8	3.45	53.4	0.116	1.8

[a] Grown without additional P_2O_5 and K_2O; $(NH_4)NO_3$ supplied.
[b] 2 tons per 2,000,000 lb. of soil without repetition.

Table III. Red Clover Response and Composition (Crop 3)[a] as Influenced by Incorporations of Conditioner

Conditioner		Dry	P_2O_5		Calcium		Magnesium		Potassium		Sodium	
Input, %	*Placement in soil*	*Weight, G.*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*	*Content, %*	*Uptake, lb./acre*
					Clarksville Silt Loam, Unlimed							
None	...	3.0	0.56	4.2	1.65	12.4	0.45	3.38	2.35	17.2	0.035	2.5
0.02	Upper half	3.0	0.54	4.1	1.65	12.3	0.41	3.04	2.38	17.7	0.038	2.9
0.05	Upper half	3.7	0.57	5.3	1.56	14.3	0.48	4.39	2.21	20.2	0.051	4.7
0.10	Upper half	4.7	0.58	6.8	1.53	17.5	0.44	5.13	2.19	25.6	0.156	18.1
0.02	Full depth	3.6	0.53	4.8	1.55	14.0	0.45	4.02	2.52	22.8	0.037	3.3
0.05	Full depth	3.5	0.58	5.1	1.51	13.1	0.41	3.59	2.34	20.2	0.102	8.7
0.10	Full depth	4.1	0.57	5.9	1.47	15.2	0.43	4.49	2.34	24.2	0.163	16.5
					Clarksville Silt Loam[b], Limestoned							
None	...	5.8	0.53	7.7	2.25	32.6	0.35	5.04	1.46	21.0	0.037	5.3
0.02	Upper half	5.9	0.53	7.9	2.15	31.6	0.37	5.50	1.69	25.0	0.041	6.1
0.05	Upper half	5.9	0.57	8.5	1.95	28.8	0.45	6.65	1.74	25.3	0.053	7.9
0.10	Upper half	6.0	0.57	8.5	2.13	31.6	0.41	6.15	1.99	29.6	0.062	9.2
0.02	Full depth	5.8	0.54	7.9	2.14	31.0	0.39	5.64	1.82	26.2	0.038	5.0
0.05	Full depth	5.5	0.57	7.9	2.02	28.0	0.41	5.73	2.09	28.8	0.060	8.4
0.10	Full depth	5.5	0.63	8.6	1.92	26.3	0.41	5.64	2.20	30.0	0.083	11.4

[a] All pots received P_2O_5 and K_2O through surface applications of solution of KH_2PO_4 after seeding of red clover.
[b] 2 tons per 2,000,000 lb. of soil, without repetition.

Table IV. Rye Grass Response and Composition (Crop 4) as Influenced by Incorporations of Conditioner

Conditioner Input, %	Conditioner Placement in soil	Dry Weight, G.	P_2O_5 Content, %	P_2O_5 Uptake, lb./acre	Calcium Content, %	Calcium Uptake lb./acre	Magnesium Content, %	Magnesium Uptake, lb./acre	Potassium Content, %	Potassium Uptake, lb./acre	Sodium Content, %	Sodium Uptake, lb./acre
Clarksville Silt Loam[a], Unlimed												
None	...	9.0	0.41	9.2	0.96	21.5	0.31	6.9	1.11	25.1	0.17	3.7
0.02	Upper half	10.4	0.38	10.0	0.82	21.3	0.26	6.7	0.96	25.0	0.56	14.5
0.05	Upper half	10.6	0.38	10.2	0.73	19.5	0.27	7.1	0.86	22.6	1.13	29.8
0.10	Upper half	10.5	0.46	12.0	0.69	18.0	0.23	6.1	0.63	16.4	1.53	40.1
0.02	Full depth	9.2	0.38	8.8	0.73	16.8	0.26	6.0	0.98	22.7	0.83	19.3
0.05	Full depth	10.2	0.41	10.4	0.68	17.2	0.24	6.0	0.90	22.9	1.36	34.6
0.10	Full depth	10.7	0.42	11.3	0.57	15.3	0.22	5.8	0.92	24.6	1.93	51.3
Clarksville Silt Loam[a,b], Limestoned												
None	...	13.6	0.32	10.9	1.10	37.1	0.27	9.0	0.57	19.5	0.15	5.0
0.02	Upper half	12.0	0.40	11.9	1.08	32.2	0.30	8.9	0.61	18.1	0.52	15.4
0.05	Upper half	12.5	0.40	12.3	0.98	30.5	0.26	8.1	0.59	18.0	0.97	35.1
0.10	Upper half	12.3	0.42	13.0	0.88	27.2	0.24	7.3	0.61	18.7	1.55	48.0
0.02	Full depth	12.3	0.40	12.2	1.01	30.1	0.27	8.3	0.62	19.1	0.87	26.6
0.05	Full depth	12.3	0.41	12.8	0.96	30.0	0.27	8.4	0.59	18.2	1.03	44.6
0.10	Full depth	13.4	0.41	13.8	0.65	21.6	0.24	8.0	0.53	17.8	1.67	55.6

[a] Received only top dressing of ammonium nitrate.
[b] 2 tons per 2,000,000 lb. of soil, without repetition.

second harvest of red clover (crop 3) registered, as did the initial crop for both the upper-half and full-depth placements of the polymer. However, in five of the six cases, larger crops caused greater uptakes of calcium in the unlimed series, but this did not occur in the limestoned series. In the twelve comparisons for the rye grass responses (Table IV) the polymer also induced diminutions in the percentage content of calcium and in its uptake. In Table V the calcium uptake values of Tables I to IV are tabulated jointly for the unlimed and limestoned series and register downward trend as rate of polymer input was increased, with significant effects indicated from the 0.05 and 0.10% inputs at full depth.

Magnesium percentages in the initial crop of red clover were about a third of the corresponding percentage for calcium, and, therefore, the differences registered in the downward trend for magnesium by the 0.05 and 0.10% inputs of the polymer were smaller; but the foregoing relationships for uptake are reversed by the values for the red clover of crop 3 on the limestoned soil. The conditioner caused lessenings of magnesium content in the millet (crop 2) from the unlimed and limestoned soils with similar though smaller effects in the rye grass (crop 4).

In Table V summations for the unlimed and the limestoned cultures, the repressions exerted by the 0.5 and 0.10% inputs at full depth are rated as significant.

Potassium increases in content and in uptake by the first crop of clover (Table I) were induced by the 0.05 and 0.10% inputs in the upper-zone and full-depth placements on the unlimed and limestoned series, and similar substantial increases occurred in the second crop of clover on the limestoned soil. Substantial increases in percentage content of potassium of the millet (crop 2) and its uptake were induced by the inputs of polymer in the twelve comparisons on the limestoned Clarksville soil.

In contrast, the polymer lessened the potassium content of the rye grass and uptake of potassium by it (Table IV) in the unlimed soil, whereas the values for potassium in the limestoned soil were indecisive. This may reflect the fact that the three preceding crops had brought exchangeable potassium to a low level or that maximal release of polymer-derived sodium per crop occurred during the growth of the fourth crop, and that magnesium between the two monovalent cations was then most pronounced.

Sodium occurrences in the four successive crops were increased by the incorporated polymer. Percentage content and uptake increases were largest in the fourth crop; but this does not prove that the rye grass had a feeding power beyond that of either of the three previous crops. The immediately preceding cultures of red clover had shown substantial increases in sodium uptake and the effect of the decomposition of the clover residues, and the longer interval between input and fourth harvest, may have caused the greater uptake of sodium by the rye grass. Its increase of 50.6 pounds in sodium uptake per acre represented 78% of the maximal aggregate for the four crops, and 19% of the input by the 0.1% full-depth incorporation of the conditioner in the limestoned Clarksville soil.

In each comparison for uptake of sodium from the incorporations of the polymer at the rates of 0.02, 0.05, and 0.1% in the series of Table V, the larger uptake of sodium was from the limestoned soil. The three comparisons for sodium uptake from the unlimed and limestoned series were, 22 *vs.* 27% for the 52.8-pound input, 23 *vs.* 32% for the

Table V. Summary of Mean Values for Response and Uptake by Four Crops on Clarksville Soil, Unlimed and Limestoned

(As detailed in Tables I to IV)

Conditioner		Clarksville Silt Loam, Unlimed and Limestoned					
			Uptake Pounds per Acre, Total 4 Crops				
Input, %	Placement in soil	Dry weight, g.	P_2O_5	Ca	Mg	K	Na
None	...	31.1	32.2	101.3	39.1	139.3	9.9
0.02	Upper half	32.0	34.1	102.0	39.2	148.3	21.5[a]
0.05	Upper half	31.7	34.3	95.0	37.6	150.2	40.5[a]
0.10	Upper half	32.5	36.3[a]	94.3	37.0	156.5	62.1[a]
0.02	Full depth	31.5	33.8	95.4	38.2	150.6	29.2[a]
0.05	Full depth	31.0	34.1	89.2[a]	35.2[a]	158.3[a]	51.6[a]
0.10	Full depth	31.7	35.1[a]	81.1[a]	33.2[a]	155.9[a]	74.9[a]
L.S.D.[b], at 5% level, as determined by analysis of variance		1.8	2.4	7.2	3.1	6.4	6.5

[a] Significant value in relation to control.
[b] Least significant difference.

Table VI. Red Clover Response and Composition, as Influenced by Incorporations of Conditioner[a] in Seven Soils

Silt Loam	Conditioner, 0.05%	Dry Weight, G.	P_2O_5 Content, %	P_2O_5 Uptake, lb./acre	Calcium Content, %	Calcium Uptake, lb./acre	Magnesium Content, %	Magnesium Uptake, lb./acre	Potassium Content, %	Potassium Uptake, lb./acre	Sodium Content, %	Sodium Uptake, lb./acre
					Unlimed							
Maury	None	6.9	0.80	13.9	3.21	55.8	0.35	6.0	1.24	21.5	0.040	0.7
	Added	7.3	0.71	13.0	2.85	52.0	0.32	5.9	1.43	26.1	0.054	1.0
Mountview	None	5.6	0.40	5.7	2.30	32.2	0.32	4.0	1.34	18.7	0.040	0.6
	Added	8.3	0.50	10.3	1.84	38.0	0.22	4.6	1.52	31.4	0.326	6.8
Maury	None	3.0	0.33	2.6	2.40	18.3	0.38	2.9	1.26	9.6	0.053	0.4
	Added	4.9	0.32	4.6	2.04	25.0	0.37	4.6	1.62	19.7	0.076	0.9
Delrose	None	7.1	0.48	8.6	2.29	40.6	0.37	6.5	0.77	13.6	0.037	0.7
	Added	8.1	0.47	9.5	2.14	43.2	0.33	6.6	0.97	19.6	0.135	2.7
Baxter	None	8.3	0.48	10.0	2.12	44.0	0.54	11.2	0.97	20.1	0.038	0.8
	Added	9.6	0.49	11.8	1.68	40.2	0.48	11.4	1.25	29.9	0.189	4.5
Baxter	None	7.4	0.53	9.9	2.80	51.0	0.42	8.0	0.80	14.8	0.047	0.9
	Added	8.9	0.52	11.5	2.16	48.4	0.39	8.7	0.95	21.2	0.199	2.0
Dickson	None	11.7	0.56	16.3	2.56	74.6	0.31	8.9	0.75	21.9	0.039	1.1
	Added	11.6	0.51	15.1	2.20	64.1	0.22	6.5	1.18	34.3	0.112	3.3
					Limestoned[b]							
Maury	None	7.9	0.61	12.2	3.24	64.5	0.53	10.5	1.06	21.0	0.041	0.8
	Added	8.1	0.61	12.7	2.88	58.9	0.49	10.0	1.38	28.1	0.051	1.0
Mountview	None	9.6	0.53	12.6	2.62	62.8	0.46	11.0	1.12	26.9	0.040	1.0
	Added	9.6	0.50	12.1	2.10	50.5	0.41	9.7	1.42	34.1	0.182	1.8
Maury	None	6.7	0.42	7.1	2.46	41.1	0.48	8.1	0.94	15.6	0.039	0.7
	Added	5.9	0.41	6.3	2.00	29.7	0.48	7.1	1.27	18.8	0.043	0.7
Delrose	None	10.7	0.64	17.1	2.74	72.8	0.64	16.9	0.76	20.8	0.44	1.2
	Added	10.9	0.62	16.9	2.31	63.2	0.58	15.8	0.94	25.7	0.149	4.1
Baxter	None	4.0	0.36	3.7	2.39	24.2	0.56	5.7	0.79	8.0	0.054	0.6
	Added	6.4	0.43	7.1	1.96	31.8	0.57	9.4	1.13	18.2	0.192	3.0
Baxter	None	8.0	0.53	10.6	2.76	55.2	0.55	10.9	0.74	14.7	0.043	0.9
	Added	8.7	0.53	11.5	2.32	50.5	0.50	10.9	0.97	21.1	0.160	3.5
Dickson	None	12.6	0.56	17.6	2.48	77.4	0.30	9.4	0.74	23.3	0.030	1.0
	Added	13.9	0.56	19.5	2.17	75.6	0.31	10.6	1.12	38.8	0.097	3.4
L.S.D., 5% level[c]		1.3		1.3		8.8		2.5		3.5		1.9

[a] At rate of 0.05% per 2,000,000 lb. of soil, in full depth.
[b] Full depth incorporation at rate of 2 tons per 2,000,000 lb. of soil made before seeding of four preceding crops.
[c] As determined by analysis of variance.

132-pound input, and 19 *vs.* 25% for the 264-pound input.

Experiment II

The polymer and method of its full-depth incorporation rate of 0.05% were as described for Experiment I. The seven silt loams had been cropped four times in a green house experiment. Six of them had pH values of 5.1 to 5.5, but the limestoned soils showed pH values of near 6 at harvest time, against pH 7 for the Dickson soil. The upper Maury soil and the Maury soil third in Tables VI and VII had phosphorus pentoxide contents of 5.08 and 0.55%, respectively, and corresponding fluorine contents of 3344 and 260 p.p.m. The incorporations of the concentrated superphosphate and potassium sulfate were the same as those stipulated in Table I, but were made full depth without a second incorporation of limestone.

Results Plant response, percentage contents, and pound-per-acre uptakes of phosphorus pentoxide, calcium, magnesium, potassium, and sodium for the successive crops of red clover and millet from the seven soils are given in Tables VI and VII.

The polymer caused some increases in plant growth in eleven of the fourteen comparisons for clover; in eight of the comparisons for millet, only the increases on the Mountview and Delrose soils were significant.

Phosphorus content of the red clover was increased by the polymer in only one case in the unlimed soils and in one case in the limestoned soils. In five cases the larger crops caused increases in the uptakes of phosphorus by the clover on the unlimed soils, against some increases in phosphorus uptake by the clover on four of the limestoned soils.

The polymer caused increases in the percentage of phophorus pentoxide in three of the succeeding millet crops from the seven unlimed soils and without positive increases in uptakes. The conditioner caused positive percentage increases of phosphorus pentoxide in only two of the seven comparisons for millet on the limestoned soils and one significant increase in uptake.

Calcium content in the clover was lessened percentagewise by the conditioner in all fourteen comparisons, and in twelve of the corresponding crops of millet on the unlimed and limestoned soils. However, in three cases in the unlimed series, and in a single case among the limestoned series, the larger crops of clover resulted in somewhat larger uptakes of calcium, none of which was significant.

The conditioner lessened the percentage of calcium in the millet from six of the seven unlimed soils, the exception being the harvest from the second Baxter soil. That harvest and the larger crops of millet from the Mountview and Delrose soils caused increases in the uptakes of calcium from the unlimed polymer-treated soils. The calcium percentages were lessened also in six of the crops of millet from the seven limestoned soils, as were the corresponding uptakes, the exception again being an increase in uptake of calcium by the Baxter soil.

Magnesium content was decreased percentagewise by the polymer in all the clover harvests from the unlimed soils and in four harvests from those limestoned (Table VI). In five of the fourteen comparisons, however, larger yields caused slightly greater uptakes of magnesium from the polymer-treated soils. Similar results for magnesium uptakes were registered by two harvests of clover on the limestoned soils.

The conditioner also lessened the magnesium contents in the fourteen comparisons for the succeeding millet crops on unlimed and limestoned soils (Table VII), although larger crops caused small increases in the uptake of magnesium by the millet on the unlimed Mountview and Delrose silt loams.

Potassium occurrence in and uptake by red clover were increased substantially by the conditioner in the fourteen comparisons for the unlimed and limestoned silt loams (Table VI). The conditioner also caused increases in percentage content of potassium in the following crops of millet from four of the seven unlimed soils and from all of the seven limestoned soils, with corresponding increases for potassium uptake in twelve of the fourteen comparisons in the two series of Table VII.

Sodium percentages were considerably higher in the harvests of clover from the fourteen cultures that contained the conditioner in both series of Table VI, and the corresponding uptakes were enhanced by the polymer in thirteen of the fourteen comparisons. Similar effects as to percentage contents of sodium and its uptake were shown by the succeeding harvests of millet in the fourteen comparisons of Table VII. Apparently the enhanced uptake of sodium followed the hydrolysis of the conditioner, because its cation content registered much the same effect that corresponding quantities of sodium as sodium hydroxide would have exerted upon the concomitant ions of calcium, magnesium, and potassium in the soil, and upon their migrations into the above-ground growth of the several crops.

Summary

In Experiment I, chemical effects of half- and full-depth three-rate incorporations of a representative soil conditioner upon plant composition were determined through analyses of four successive crops from unleached pot cultures, unlimed and limestoned.

Inputs of 0.02% of the polymer loam were without decided effect upon percentage content of calcium, magnesium, and phosphorus pentoxide in the four successive crops; but the 0.05 and 0.1% inputs caused decided diminutions in calcium and magnesium contents. In marked contrast were the potassium increases in the successive crops of clover, millet, and clover, with opposite indication by the crops of rye grass.

The polymer caused progressive increases in sodium content and uptake in the four-crop succession. Largest uptake per crop was 50.6 pounds in the fourth crop (rye grass), and maximal four-crop recovery of the sodium of the polymer was 65 pounds from the 0.1% full-depth incorporation. Total recoveries of sodium from the 0.02, 0.05, and 0.1% incorporations of polymer were 22, 23, and 19%, respectively, for the unlimed Clarksville silt loam and 27, 32, and 25%, respectively, for the limestoned soil.

In Experiment II, the 0.05% full-depth inputs of the polymer registered percentage decreases for calcium and magnesium contents in successive crops of red clover and millet on seven unlimed and limestoned silt loams, while inducing increases in potassium uptake in 26 of the 28 comparisons.

Table VII. Response by and Composition of Succeeding Crop of Millet, as Influenced by Incorporations of Conditioner[a] in Seven Soils

Silt Loam	Conditioner, 0.05%	Dry Weight, G.	P_2O_5 Content, %	P_2O_5 Uptake, lb./acre	Calcium Content, %	Calcium Uptake lb./acre	Magnesium Content, %	Magnesium Uptake, lb./acre	Potassium Content, %	Potassium Uptake, lb./acre	Sodium Content, %	Sodium Uptake, lb./acre
					Unlimed							
Maury	None	13.4	1.05	35.4	0.97	32.5	0.64	21.5	1.20	40.2	0.037	1.2
	Added	12.9	1.00	32.6	0.78	25.2	0.52	16.8	1.08	34.9	0.073	2.4
Mountview	None	11.5	0.42	11.5	0.94	26.9	0.45	12.9	1.17	33.7	0.038	1.1
	Added	14.3	0.49	17.5	0.83	29.5	0.38	13.6	1.02	36.2	0.221	7.9
Maury	None	7.2	0.43	7.7	1.43	25.8	0.58	10.5	1.99	34.9	0.049	0.9
	Added	8.4	0.45	9.4	1.23	25.5	0.54	10.1	1.56	31.7	0.182	3.7
Delrose	None	10.5	0.70	18.4	1.11	29.2	0.78	20.8	0.37	9.6	0.030	0.8
	Added	12.1	0.73	22.1	1.05	31.8	0.74	22.4	0.59	17.6	0.136	4.1
Baxter	None	12.3	0.49	15.2	0.90	27.8	1.02	31.5	0.42	12.9	0.030	0.9
	Added	12.7	0.50	15.9	0.83	26.4	0.90	28.6	0.51	16.0	0.093	3.0
Baxter	None	12.6	0.64	20.2	0.95	30.9	0.82	25.8	0.54	16.9	0.051	1.6
	Added	11.9	0.65	19.1	1.07	31.9	0.69	20.6	0.58	17.3	0.140	4.2
Dickson	None	7.3	0.63	11.6	1.32	24.2	0.49	9.0	0.67	12.2	0.068	1.3
	Added	7.9	0.64	12.6	1.15	22.5	0.44	8.7	0.81	15.9	0.224	4.4
					Limestoned[b]							
Maury	None	14.8	1.13	42.3	0.89	32.9	1.08	39.9	0.95	35.0	0.037	1.4
	Added	14.8	1.15	42.5	0.82	30.2	0.99	36.5	1.08	39.6	0.077	2.8
Mountview	None	12.1	0.53	16.1	1.11	33.7	1.10	33.4	1.00	30.4	0.032	1.0
	Added	12.5	0.47	14.7	1.02	31.9	0.90	28.2	1.01	31.6	0.117	3.7
Maury	None	9.4	0.53	12.5	1.27	29.5	0.95	22.1	1.25	28.9	0.050	1.2
	Added	9.2	0.60	13.6	1.18	27.0	0.93	21.2	1.69	38.5	0.128	2.9
Delrose	None	13.4	0.66	22.0	1.01	33.9	1.27	42.7	0.26	8.7	0.033	1.1
	Added	13.6	0.65	22.2	0.95	32.5	1.21	41.3	0.36	12.4	0.082	2.8
Baxter	None	15.7	0.42	16.7	0.90	35.2	1.39	54.5	0.34	13.4	0.034	1.3
	Added	14.6	0.47	17.2	0.80	29.1	1.25	45.5	0.71	25.8	0.060	2.2
Baxter	None	12.4	0.53	16.4	0.98	30.6	1.15	35.9	0.47	14.8	0.043	1.4
	Added	12.4	0.54	16.6	1.03	32.1	0.99	30.8	0.56	17.6	0.114	3.6
Dickson	None	8.3	0.67	14.1	1.17	24.4	0.68	14.2	0.35	7.3	0.044	0.9
	Added	9.3	0.66	15.5	0.97	22.7	0.61	14.2	0.36	8.7	0.134	3.1
L.S.D., 5% level[c]		1.6		2.5		4.2		3.5		8.3		1.0

[a, b] See Table VI.
[c] As determined by analysis of variance.

In 27 of 28 comparisons, the polymer caused decided increases in uptakes of sodium from the seven silt loams, and in all cases the larger uptakes of sodium were from the limestoned soil.

The findings demonstrate capacity of the additive sodium to repress uptake of calcium and magnesium, while causing increase in the uptake of potassium by the above-ground growth of the several crops; substantial soil retention of the sodium of the polymer throughout the growth of three successive crops; and appreciable passage of the polymer sodium into the fourth of four crops.

In general, decisive effects upon the chemical compositions of the several crops were induced only by the 0.05 and 0.1% inputs. No substantial repressions in plant response were indicated, and the incorporated polymer functioned in like manner in the unlimed and limestoned soils.

The pot cultures of Experiments I and II were not subjected to leaching and the crops were feeding upon sodium contents that were different from those upon which the several vegetations would have been growing in soils subjected to natural rainfall, or to a simulation of it.

The two experiments demonstrate that the incorporated polymer induced changes in the proportions of the cations that prevailed in solute and exchangeable forms in the soil. Therefore, the authors believe it essential to obtain a comprehensive inventory and understanding of the chemical and biochemical effects of incorporations of soil conditioners, sodium or potassium. It is believed those objectives could be attained through lysimeter experiments conducted at several points where soil type and reaction and rainfall are the controlling factors, with parallel fallow and cropping. Such an experimental approach should indicate to what extent rain-water leachings and plant uptake govern persistence and fate of an incorporated polymer and correlate the physical effects induced by the polymer.

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PIG NUTRITION

Selection of Diet for Studies of Vitamin B_{12} Depletion Using Unsuckled Baby Pigs

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THE BABY PIG has been used extensively and very successfully as an experimental animal in nutritional research. However, most of the reported studies involved pigs which were allowed to nurse for 1 or 2 days before being put on an experimental diet. In studying nutritional factors which are accumulated or stored, it would be desirable to start the animal on the nutritional regime immediately after birth. Early attempts by other workers to raise baby pigs taken at birth were unsuccessful (*1*, *10*), and colostrum was considered essential for survival.

Young and Underdahl (*20*) have recently demonstrated that pigs which have not nursed can be raised on supplemented cow's milk if the animals are separated from the dam and the herd environment at birth and are maintained in strict isolation. Their work indicated that the essential feature of colostrum involves protection against disease by antibody transfer, and therefore colostrum is not necessary if exposure to disease is prevented by adequate isolation. To accomplish this separation the pigs were caught at birth in sterile bags, or more recently removed from the sow by hysterectomy (*19*), and placed immediately in an isolated environment.

Sheffy *et al.* (*17*) have reported the successful rearing of 12 pigs to the age of 4 weeks on a semisynthetic diet. Their work indicated that phospholipides were necessary for survival, and their ration contained antibiotics. Catron and coworkers (*5*) successfully raised 14 pigs without colostrum to 8 weeks of age on a supplemented skim milk ration, but were unable to repeat their experiment because of disease interference. The present paper relates experience in raising newborn pigs on purified diets using moderate isolation procedures, and presents evidence of having obtained a definite depletion of vitamin B_{12} reserves using this technique.

Methods

Preparation of Rations In experiments I and II the cow's milk fed was commercial homogenized "vitamin D" milk supplemented with mineral salts and egg as

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