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P-Influx in Different Crops on Alfisols and Inceptisols

S. C. MEENA[1], H. S. PUROHIT, R. S. YADAV, R. K. BAGRI AND V. BANSAL

Krishi Vigyan Kendra, Jhalawar, Rajasthan

Abstract

Pot study was carried out to assess the P- influx in different crops on Alfisols and Inceptisols, using complete randomized block design with four replications. The physico-chemical properties of the soils are pH 7.90, EC 0.35 dS/m, av P 10.45, av K 230.60 kg/ha for Alfisols and pH 7.80, EC 0.50 dS/m, av P 17.20, av K 285.90 kg/ha for Inceptisols. A significant difference in phosphorus influx. Although, the changes due to plant growth in phosphorus assimilation during crop growth was higher in alfisols. The fumigation levels (i.e. $B_4$and B_5) were also significantly altered the root growth and phosphorus assimilation. The P-influx was highest up to 15—30 DAS and after that it was drastically reduced up to harvest suggested that highest P requirement for plant growth was up to 15—30 DAS of crop growth presumably for root development.
Key words : Microorganism, Phosphorus mobilization, Soils, Crops.

Phosphorus is an important nutrient in crop production. It promotes plant root growth and help in energy transformations and photosynthesis of plant. The function of phosphorus as a constituent of macromolecular structures is most prominent in nucleic acids, which, as units of the DNA molecule, are the carriers of genetic information and, as units of RNA, are the structures responsible for the translation of the genetic information. The major problem of phosphorus is its availability. The P cycle in soil is a dynamic system involving soils, plants and microorganisms. Major processes include uptake of soil P by plants, recycling through return of plant and animal residues, biological turnover through mineralization-immobilization, fixation reactions at clay and oxide surfaces, and solubilization of mineral phosphates through the activities of microorganisms. Chemical and biochemical aspects of the P cycle have been reviewed from several stand points, including fluxes of P on a global scale (1), pedogenesis (2), plant nutrition (3) and inorganic forms and fixation reactions (4), soil organic P and associated transformations (5). Phosphorus (P) is one of the major limiting factors for plant growth. The P transformations in soil involve complex processes like physical, chemical and biological. Plant availability of inorganic phosphorus (Pi) can be limited by formation of sparingly soluble Ca-phosphate, particularly in alkaline and calcareous soil ; by adsorption to Fe and Al-oxide surfaces in acid soils, and by formation of Fe/Al-P complexes with humic acids (6). Organic forms of phosphorus constitute a large proportion of soil P (often 20—80% of total soil P (7). Plant roots acquire P as Pi from the soil solution. Thus, to contribute to plant P nutrition, soil P must be dephosphorylated by phosphatase or phytase, which may be of plant and microbial in origin (8).

Methods

The present investigation was under taken with two soil types belongs to soil order Alfisols and Inceptisols. The soils of these two orders dominate the maximum parts of Rajasthan, Further to find out the contribution of dominated crops in the state were selected. The four crops viz. maize, sorghum, wheat and mustard were used in order to evaluate the P-influx.

The rhizosphere and non-rhizosphere soil samples from the fields having all the four crops under study representing both the soil types were collected. These samples were analyzed for p fractions and mobilization at different crop growth stages for precised interpretations of pot experiment results.

Uptake of Phosphorus

The uptake of phosphorus contents was calculated by using the data per cent phosphorus and dry matter yield. The formula for calculation is as follows :

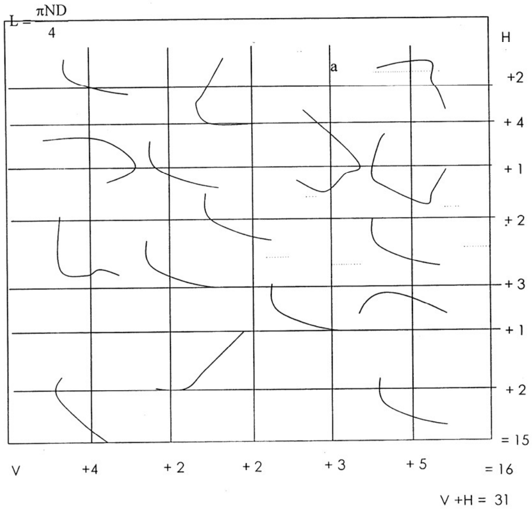

Figure 1. Line intercepy method for determining root length.

Uptake of phosphorus = Dry matter yield (g/pot) × Phosphorus content (per cent) × 10 (mg/pot)

Root Length

Root length was measured, using the line intercept method. Principle of this method is that root length can be estimated by counting the number of interscetions between roots and sample lines. In this method roots were spread out with random orientation in a thin layer of water on a glass plate (about 25 × 25 cm) marked in grid lines. All intersection of roots with gird lines (taking the upper or left boundary of the line as criterion in case of doubt) are counted (Fig. 1). Results for horizontal (H) and vertical (V) grid lines are added to number N. If the grid size was D (mm), root length L (mm), then the equation stands :Line intercept method for determining root length by counting the number of interceptions between roots and horizontal (H) plus vertical (V) lines of a grid.

Computation of Plant Growth Parameters

The root weight, shoot weight and root : shoot ratios were calculated on dry weight basis. The P inflow/influx was expressed per unit root length (cm) and time (second) between the two consequent harvestings/samplings. The P-influx was calculated using the formula as follows :

$$\text{P - Influx} = \frac{u_2 - u_1}{L_2 - L_1} \times \frac{l_n\left(\frac{L_2}{L_1}\right)}{t_2 - t_1}$$

Where u_2 - u_1 (ΔU) is the change in P-uptake (mol plant^{-1}), L_2 - L_1 (ΔL) is the change in total root length (cm/plant) at t_1 and t_2 and $t_2 - t_1$ (Δt) the change in time (second). The P-influx was expressed as (mol/cm root/s).

Results and Discussion

Roots Length

The results revealed that root length (cm) of different plant species was significantly increased with plant growth up to 30—45 DAS maximum then decreased order up to harvest under both the factors i.e. soil types and fumigation levels (Tables 1). About 5 to 20 times increased in root length under different plant species with highest under wheat (17.8 to 18.2 times) followed by maize (10.50 to 10.7 times) and sorghum (10.6 to 10.8) and least under mustard (4.7 to 5.8 times) but over all the growth stages in maize crop root length is highest both in alfisols and in inceptisols. The root length was slightly higher in inceptisols than alfisols which may be due to higher availability of soil phosphorus and other essential nutrients for plant growth. Similarly, fumigation levels were also significantly altered the root length at all the growth stages of all the plant species under study which was ranges from 15.4 to 23.3 times under wheat, 3.6 to 6.3 times under mustard, 10.0 to 11.58 times under maize and 8.8 to 10.0 times under sorghum up to 45—60 DAS of growth stages. It is evident from the results that development of the root is continued till maturity but after 45 DAS decaying of older roots is started of the crops. Therefore, development and decaying of plant roots are the simultancous process up to growth of the plants. The interaction effect of soil types and fumigation levels were also significantly (P = 0.05) altered the root development of all the plant species under study).

Phosphorus Uptake

Significant difference (P = 0.05) in phosphorus

Table 1. Effect of different treatments on root length (cm/plant) under different crops.

	Wheat on DAS						Mustard on DAS					
Treatments Soil Type (A)	15	30	45	60	75	Harvest	15	30	45	60	75	Harvest
A_1	260	1532	4886	4726	4403	3677	24	94	166	150	136	119
A_2	270	1581	5199	5058	4769	3954	29	98	173	156	140	124
SE ±	2.583	18.168	36.36	40.72	33.36	34.795	0.291	1.015	1.57	1.320	1.235	1.100
LSD (P = 0.05)	7.459	52.473	105.02	117.60	96.37	100.46	0.840	2.931	4.53	3.813	3.566	3.177
Fumigations (B)												
B_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B_2	239	1536	5165	4961	4656	3870	25	88	176	166	153	131
B_3	239	1550	5820	5692	5357	4490	25	89	176	165	155	133
B_4	422	2328	6939	6810	6457	5337	41	141	192	180	170	155
B_5	427	2369	7290	6999	6459	5381	41	162	304	256	212	188
SE ±	4.083	28.726	57.49	64.38	52.75	55.00	0.460	1.605	2.48	2.088	1.952	1.739
LSD (P = 0.05)	11.794	82.968	166.06	185.95	152.38	158.85	1.329	4.634	7.17	6.030	5.638	5.023
Interaction (A × B)	16.679	117.33	234.85	262.98	215.50	224.65	1.88	6.55	10.15	8.53	7.97	7.10
	Maize on DAS						Sorghum on DAS					
Treatments Soil Type (A)	15	30	45	60	75	Harvest	15	30	45	60	75	Harvest
A_1	1538	1838	4617	4517	4299	3560	392	1837	4626	4528	4305	3566
A_2	1892	1892	4675	4589	4375	3625	405	1837	4694	4588	4384	3628
SE ±	4.71	14.76	36.56	36.05	32.36	29.39	4.13	19.94	36.05	38.07	36.05	32.36
LSD (P = 0.05)	13.62	42.63	105.60	104.14	93.46	84.89	11.94	57.60	104.12	109.95	104.14	93.46
Fumigations (B)												
B_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B_2	388	2101	4882	4774	4499	3769	387	2100	3914	4786	4507	3775
B_3	388	2101	4882	4775	4499	3769	387	2100	3914	4786	4507	3775
B_4	612	2563	6734	66.09	6345	5212	609	2561	5395	6610	6354	5218
B_5	612	2562	6734	6609	6344	5212	610	2561	5415	6610	6354	5218
SE ±	7.46	23.33	57.81	57.01	51.16	46.47	6.56	31.53	57.00	60.19	57.01	51.16
LSD (P = 0.05)	21.54	67.40	166.98	164.66	147.78	134.22	18.89	91.07	164.64	173.85	164.66	147.78
Interaction (A × B)	30.47	95.33	236.15	232.87	209.00	189.82	26.72	128.80	232.84	245.87	232.87	209.00

uptake was observed among the soil types and fumigation levels (Table 2). Generally, higher P-uptake was found in inceptisols than alfisols. However, the changes with plant growth in P-uptake were higher under alfisols under all the plant species in study. This increase was highest for wheat followed by mustard than sorghum and least in maize. Irrespective to plant species the effect of fumigation levels on phosphorus uptake was found in the order of B_2>B_3>B_4. Further , assessment of interaction effects indicates a significant (P = 0.05) impact of fumigation between the soil types and with in the soil types also under all the crops. More than 50% higher P-uptake was recorded in alfisols than inceptisols that might be due to influence of soil physico-chemical and microbiological characteristics on P-uptake (Fig. 2). Crop wise interaction effects of soil type shows a trend of 225, 235, 308 and 328% increase in P-uptake from 15 DAS to 45 DAS in maize, sorghum, nustard and wheat, respectively in alfisols where as just half was recorded in inceptisols with same order of sequence.

P-Influs

Irrespective of crops and soil a significant (p=0.05) decrease in p-influx values were recorded from 15 DAS to harvest level. Mathematically 4 to 7 fold slant decline in P influx (millimole P/Pot/Sec × 10^{-11}) was observed all fumigation and crops under both the soils. Further, examination of data reveals that highest values of P influx were recorded under winter season (*rabi)* crops than the *kharif* season that might be due

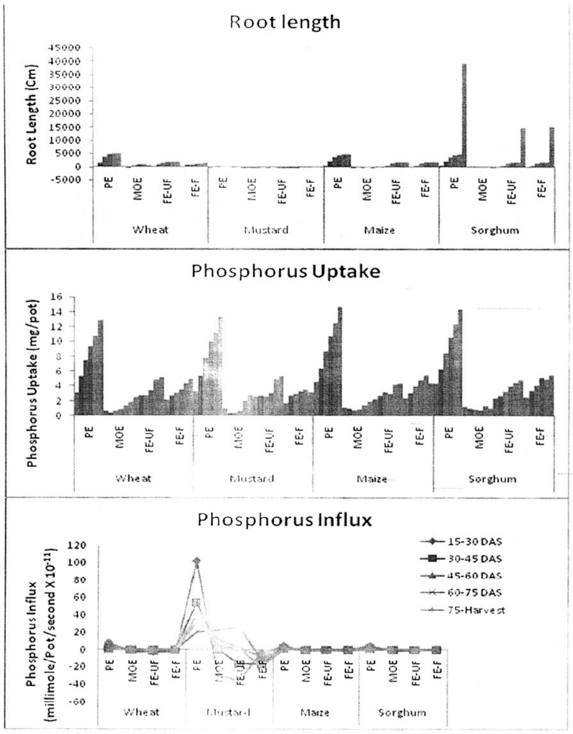

Figure 2. Effect of plants micro organisms and phosphatic fertilizers on P uptake and influx under different plant species ; PE Plant effect : MOE, microorganism effect : FE-UF, Fertilizer effect (unfumigated) : FE-F, Fertilizer effect (Fumigated).

to higher microbial influence during the same. Cereals crop under study (Maize, sorghum and wheat) shown 93-98% decrease in P influx from 15 DAS to crop harvest where as oil seed crop (mustard) shows (i.e.72—78%) decrease for the same, irrespective of both soil types and fumigation levels. The Irrespective of soil types and fumigation levels P-influx values were also found to be significant. (Table 3).

Table 2. Effect of different treatments on phosphorus uptake (mg/plant) under different crops.

	Wheat on DAS					
Treatments Soil Type (A)	15	30	45	65	75	Harvest
A_1	2.19	3.33	9.40	7.44	6.36	4.74
A_2	5.29	7.72	16.73	14.39	12.13	10.05
SE ±	0.011	0.020	0.087	0.026	0.025	0.026
LSD (P = 0.05)	0.032	0.059	0.117	0.076	0.074	0.077
Fumigations (B)						
B_1	0.0	0.0	0.0	0.0	0.0	0.0
B_2	3.15	5.30	12.88	10.66	9.33	7.47
B_3	3.86	5.74	14.73	12.08	10.29	8.10
B_4	5.70	8.03	18.03	15.46	12.80	10.18
B_5	6.00	8.56	19.69	16.41	13.82	11.23
SE ±	0.017	0.032	0.048	0.041	0.040	0.042
LSD (P = 0.05)	0.051	0.093	0.137	0.120	0.117	0.122
Interaction (A × B)	0.073	0.132	0.194	0.170	0.166	0.172

Table 2. Continued.

Treatments Soil Type (A)	15	30	Maize on DAS 45	60	75	Harvest
A_1	3.25	4.59	10.59	9.11	7.83	6.24
A_2	6.94	8.93	18.09	16.14	13.19	11.28
SE ±	0.012	0.022	0.020	0.027	0.030	0.025
LSD (P = 0.05)	0.036	0.064	0.057	0.077	0.088	0.073
Fumigations (B)						
B_1	0.0	0.0	0.0	0.0	0.0	0.0
B_2	4.65	6.48	14.78	12.58	10.68	8.72
B_3	5.75	7.47	16.70	14.12	11.63	9.58
B_4	6.95	9.25	19.17	16.82	13.73	11.89
B_5	8.14	10.58	21.04	19.61	16.50	13.62
SE ±	0.020	0.035	0.031	0.042	0.048	0.040
LSD (P = 0.05)	0.057	0.102	0.090	0.121	0.139	0.116
Interaction (A × B)	0.081	0.144	0.127	0.171	0.196	0.164

Table 2. Continued.

Treatments Soil Types (A)	15	30	Mustard on DAS 45	60	75	Harvest
A_1	2.51	3.49	10.26	8.12	6.64	4.95
A_2	5.34	7.73	16.82	15.92	12.43	10.14
SE ±	0.045	0.029	0.108	0.024	0.026	0.037
LSD (P = 0.05)	0.061	0.084	0.312	0.070	0.075	0.107
Fumigations (B)						
B_1	0.0	0.0	0.0	0.0	0.0	0.0
B_2	3.29	5.42	13.31	11.22	9.96	7.79
B_3	4.30	5.87	16.24	13.30	10.65	8.28
B_4	5.98	8.17	18.68	16.22	13.07	10.41
B_5	6.07	8.59	19.26	16.83	14.00	11.26
SE ±	0.071	0.046	0.171	0.038	0.041	0.059
LSD (P = 0.05)	0.096	0.132	0.493	0.111	0.119	0.169
Interaction (A × B)	0.135	0.187	0.697	0.157	0.168	0.239
Treatments			Sorghum on DAS			
	15	30	45	60	75	Harvest
Soil Type (A)						
A_1	3.13	4.50	10.50	9.04	7.79	6.15
A_2	6.83	8.90	17.50	15.73	13.58	11.22
SE ±	0.017	0.025	0.287	0.023	0.027	0.026
LSD (P = 0.05)	0.050	0.073	0.829	0.066	0.079	0.074
Fumigations (B)						
B_1	0.0	0.0	0.0	0.0	0.0	0.0
B_2	4.38	6.33	14.43	12.43	10.64	8.53
B_3	5.62	7.31	15.43	13.86	11.48	9.41
B_4	6.81	9.15	19.22	16.88	14.64	11.91
B_5	8.10	10.71	20.92	18.78	16.66	13.57
SF ±	0.027	0.040	0.454	0.036	0.043	0.041
LSD (P = 0.05)	0.079	0.115	1.310	0.105	0.125	0.117
Interaction (A × B)	0.111	0.163	1.853	0.149	0.177	0.166

Increased root production is a well-known acclimation of P deficient plants to improve P uptake (9) by means of high P-influx or high root : shoot ratio (10, 11). The ability to access was related to root mor-

Table 3. Effect of different treatments on P-influx (millimole P/Pot/Sex × 10^{-11}) under different crops.

Treatments	Wheat on DAS 15-30	30-45	45-60	60-75	75-harvest
Soil Type (A)					
A_1	3.256	1.206	0.803	0.450	0.401
A_2	6.749	1.822	0.946	0.910	0.457
SE ±	0.0353	0.0245	0.0304	0.0091	0.0148
LSD (P = 0.01)	0.1019	0.0708	0.0409	0.0261	0.0428
Fumigations (B)					
B_1	0.0	0.0	0.0	0.0	0.0
B_2	7.613	2.135	1.097	0.674	0.546
B_3	6.629	2.128	1.077	0.787	0.562
B_4	5.175	1.489	1.112	0.984	0.468
B_5	5.94	1.818	1.087	0.955	0.568
SE ±	0.0558	0.1119	0.0166	0.0143	0.0234
LSD (P = 0.05)	0.1611	0.1507	0.0481	0.0413	0.0676
Interaction (A × B)	0.2279	0.2131	0.0680	0.0585	0.0956

Treatments	Maize on DAS 15-30	30-45	45-60	60-75	75-harvest
Soil Type (A)					
A_1	2.789	1.233	0.806	0.599	0.662
A_2	4.091	1.821	0.933	1.262	0.869
SE ±	0.1464	0.1083	0.0388	0.0252	0.0068
LSD (P = 0.01)	0.4229	0.3128	0.1122	0.0728	0.0197
Fumigations (B)					
B_1	0.0	0.0	0.0	0.0	0.0
B_2	4.515	1.964	1.177	1.005	1.127
B_3	4.255	1.962	1.213	1.310	1.316
B_4	4.077	1.761	0.785	1.163	0.851
B_5	4.352	1.949	1.173	1.173	0.532
SE ±	0.2315	0.1713	0.0614	0.0399	0.0108
LSD (P = 0.01)	0.6687	0.4946	0.1773	0.1151	0.0312
Interaction (A × B)	0.9457	0.6995	0.2508	0.1628	0.0441

Table 3. Continued.

Treatments	Mustard on DAS 15-30	30-45	45-60	60-75	75-harvest
Soil Type (A)					
A_1	3.383	1.209	0.816	0.423	0.413
A_2	6.566	1.843	0.934	0.921	0.465
SE ±	0.0350	0.0253	0.0294	0.0092	0.0142
LSD (P = 0.01)	0.1037	0.0732	0.0415	0.0263	0.0432
Fumigations (B)					
B_1	0.0	0.0	0.0	0.0	0.0
B_2	7.756	2.234	1.086	0.687	0.525
B_3	6.589	2.234	1.054	0.768	0.534
B_4	5.123	1.398	1.087	0.968	0.432
B_5	5.569	1.786	1.036	0.911	0.543
SE ±	0.0551	0.1112	0.0154	0.0139	0.0225
LSD (P = 0.01)	0.1601	0.1502	0.0471	0.0407	0.0646
Interaction (A × B)	0.2221	0.2112	0.0654	0.0546	0.0918

Table 3. Continued.

Treatments Soil Type (A)	Surghum on DAS 15-30	30-45	45-65	60-75	75-harvest
A_1	2.873	1.235	0.857	0.558	0.394
A_2	4.266	1.728	1.164	0.993	0.442
SE ±	0.0287	0.0347	0.0170	0.0071	0.0047
LSD (P = 0.01)	0.0829	0.1002	0.0491	0.0206	0.0137
Fumigations (B)					
B_1	0.0	0.0	0.0	0.0	0.0
B_2	4.741	1.894	1.283	0.948	0.613
B_3	4.124	1.837	1.253	1.258	0.488
B_4	4.234	1.813	1.174	0.860	0.516
B_5	4.748	1.865	1.342	0.813	0.474
SE ±	0.0454	0.0549	0.0269	0.0113	0.0075
LSD (P = 0.01)	0.1310	0.1584	0.0776	0.0326	0.0216
Interaction (A × B)	0.1853	0.2240	0.1098	0.0462	0.0305

phology and development. The differences in P influx can be explained by differences in their uptake kinetics. Influence of P-status on uptake efficiency would be attributed to the change in root and shoot parameters of the plant. Also the higher value of plant uptake parameters at initial plant growth may be due to seed P uptake. Although, the genetic differences in the transport systems would also differ the uptake characteristics. The genotypic differences in nutrient uptake have been reported in many herbaceous species (12, 13). It is still unclear whether these differences were a result of differences in the transport systems or in growth and nutrient demand.

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