EFFECT OF P FERTILIZATION ON AVAILABLE P AND YIELD OF WHEAT AND SUBSEQUENT MAIZE CROPS IN DIFFERENT TARAI AND BHABAR SOILS OF UTTARAKHAND

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ABSTRACT

A pot experiment was conducted to study the effect of P fertilization on available P status and yield of wheat and subsequent maize crops in different soils (twenty two from tarai and five from bhabar) of Uttarakhand. After harvest of wheat and maize crops the contents of available P in each individual soil under different treatments were in the order of P_3>P_2>P_1>P_0. The decrease under P_0 and increase at each successively higher level was highly significant. The decline under control and buildup under P application did not differ appreciably between tarai and bhabar soils. On an average there was slightly more depletion in available P under P_0 and slightly less increase under P_1, P_2, and P_3 in tarai soils than in bhabar soils. The depletion in initial P present was greatest at P_1 both in tarai (21.4 %) as well as in bhabar (26.0 %) soils. The influence of P application on dry matter yield of wheat was more pronounced at lower doses, however, it was significant at each successive level. The residual effect of P on dry mater yield of successive crop maize was also significant up to P_3 level.

Key words : Available P, P fertilization, tarai soils, bhabar soils, wheat , maize, dry matter yield

The phosphorous is both an essential and a frequently limiting for crop production. It plays an important role as a source of energy, structural component of the cell constituents and metabolically active plant compounds. Besides being a constituent of the nucleic acids, which control all life processes, phosphorous plays many other key roles in the plant life. The significant role of fertilizer P in sustaining and building up of soil fertility, particularly under intensive system of agriculture has been amply demonstrated (Chhabra, 1985: Saggar et al., 1986).

The response of crops to P is further governed by rate, time and method of application. The dose of P for optimum responses varies with the crops and available P status of soil. The response of P varies with crops at different places. It was more in rabi than kharif crops and more in irrigated than un-irrigated crops (Meelu et.al., 1979).

Amount and longevity of the residual effect of P depends primarily upon rate, duration and frequency of P application, solubility of the P fertilizer, soil properties, types of crops, yield levels and extent of P removals.

Under Indian conditions, residual effect of fertilizer P additions have been observed up to 1-10 successive crops (Sharma et.al., 1983; Singh and Brar, 1986). The residual P was half as effective as freshly added P (Chahal et.al., 1984)

Recommendation for P fertilization are normally based on crop response data from field and green house studies. A complete picture of crop response to P is obtained only when both the direct and the residual effects are taken into account. For efficient crop production it is essential that P or any other plant growth factor should not be limiting to enable the crop to express its full genetic potential. Moreover, under limiting resources the capital invested in any fertilization program should give maximum returns. Therefore, a knowledge about P availability in the soil is a pre-requisite for deciding the investment in this input.

MATERIALS AND METHODS

Bulk surface (0 - 0.15 m) soil samples varying in texture, pH and organic carbon were collected from twenty two sites of tarai (serial number 1 to 22) and five sites from bhabar (serial no. 23 to 27) belts below the Siwalik ranges of Himalayas in Udham Singh Nagar and Nainital districts of Uttarakhand. Soils were analyzed (Table 1) for relevant general characteristics by usual chemical methods. For free iron oxides CBD and for total P HF-HCIO4 methods were used. Available P was extracted by the $NaHCO_3$ solution (Olsen et al. 1954) and concentration of P was determined by Murphy and Riley (1962) method.

Wheat (cv. UP 2338) was sown in plastic pots containing 4.5 kg soil, and thinned after 10 days to maintain four plants in each pot. The treatments included 10 (P_1), 20 (P_2) and 30 (P_3) mg P kg^{-1} soil, respectively, applied through single super phosphate, and a P control (P_0), all replicated twice in the completely randomized design. Each pot was supplied with 60 mg N kg^{-1} and 16.6 mg K kg^{-1} soil. At 64 days, plants were harvested, washed with deionized water, oven dried and weighed.

Prior to sowing the succeeding crop, soil samples (approximately 50 g each) were collected from all the pots. The samples were immediately air dried and crushed to pass through 2 mm sieve. Maize (cv. Shweta) was sown in the same pots without applying and fertilizer. Other than urea solution @ 60 mg N kg^{-1} soil at 23 days after sowing. After emergence four plants were maintained. The plants were harvested from soil level at 55 days after sowing, at presilking stage. After harvesting the plants samples were processed as in case of wheat.

RESULTS AND DISCUSSION

Physiochemical properties of soils

The Ranges and mean values of pH, EC, calcium carbonate equivalent, organic carbon, CEC, particle size distribution, free Fe_2O_3, and total P content of the initial samples from all the soils used in present study are presented in table 1. The soils were slightly acidic to slightly alkaline in reaction except soil no. 27 which had slightly low pH. The EC, calcium carbonate (%) and free iron oxide of these soils were low. The organic matter content of these soils was between medium to high range.

Effect of cropping on available P

The available P content of each soil under different treatments after harvest of wheat and maize crops have been given in table 2. After harvest of wheat and maize crops contents of available P in each individual soil under different treatment were in the order of $P_3>P_2>P_1>P_0$. Mean contents of available P under P_0, P_1, P_2

and P_3 after wheat were 19.55, 25.75, 28.46 and 30.44 mg P kg^{-1}, respectively, while mean contents of available P under P_0, P_1 P_2 and P_3 after maize were 16.91, 19.98, 22.50, and 24.85 mg P kg^{-1}, respectively and the increase at each successively higher level was highly significant. The decline was more pronounced at highest level of P application, however, it remained above the initial P level till the end. While in control it continued to decrease below the initial level in absence of P application.

Change in available P status

When compared with initial available P contents (table 3) after harvest of wheat under P_0 decreased invariably for each soil while it increased progressively under each successively greater dose of P applied. For all the soils of tarai and bhabar on an average there was depletion of 1.98 mg P kg^{-1} under P_0 from the mean initial P of 21.53 mg kg^{-1}, while there was increase of 4.21, 6.92 and 8.92 mg P kg^{-1} under $P_{1'}$ P_2 and P_3, respectively. On an average there was slightly more depletion in available P under P_0 and slightly less increase under P_1, P_2, and P_3 in tarai soils than in bhabar soils.

During the subsequent crop of maize grown without further application of P fertilizer the available P content of the soil under P_0 decreased invariably for each soil. It also decreases under P_1 in 18 soils, under P_2 in 10 soils and under P_3 in 2 soils. For all the soils of tarai and bhabar on an average there was depletion of 4.62 and 1.55 mg P kg^{-1} under P_0 and P_1, respectively from the mean initial P of 21.53 mg kg^{-1}, while there was increase of 0.97 and 3.32 mg P kg^{-1} under P_2 and P_3, respectively. The depletion in mean available P content from the initial value was also observed at P_1, while after wheat the depletion was observed only under P_0. The depletion in initial P percent was greatest at P_1 both in tarai (21.4 %) and bhabar (26.0 %) soils. Such depletion in phosphorous under control and its build up at higher values was also reported by Chhabra (1985) and Saggar et.al., (1986). The decline under control and build up under P application did not differ appreciably between tarai and bhabar soils.

Dry matter yield

The dry matter of wheat differed remarkably among treatments in tarai soils where the mean yield at 30 mg P kg^{-1} level was twice as much of that under control (table 4). Soil number 14 recorded the greatest variation in dry matter yield from P_0 to P_3. The increase in dry matter yield of wheat in bhabar soils was 66.5 percent at 30 mg P kg^{-1}, while the percent increase in dry matter yield at P_1 and P_2 were 44.0 and 63.4 percent over control, respectively. The influence of P application on dry matter yield was more pronounced at lower doses, however, it was significant at each successive level. Few soils (soil number 9, 13, 15, 25 and 26) showed maximum dry matter yield of wheat only at P_2. Similarly, Sharma et.al. (2012) reported that increasing levels of phosphorous increased the grain and straw yield up to 26 P ha^{-1} of wheat crop. The marked increased in yield with application of phosphorous is generally observed on soils deficient in available phosphorous and also when all other factors of production including rate of NKS are at optimal levels. This may be due to phosphorous attributed for the promoting formation of lateral and fibrous roots which increase root proliferation and absorbing surface nutrients. This higher absorption capacity of nutrients tends to improve the dry matter yield. Increase in yield of wheat with increasing P application in tarai of Nainital district was also reported by Singh (1970) and Sharma et.al. (1971). More response of P application was observed in P deficient soils as reported by Rai and Sinha (1979), Vig and Singh (1983) and Jaggi and Minhas (1990).

The residual effects of P application at 10, 20, and 30 mg P kg^{-1} levels in terms of dry matter yield of successive crop maize was also significant up to P_3 level (table 4). However, P application could increase the dry matter yield of maize only up to 20.7 and 9.6 percent in P_3 over control in tarai and bhabar soils, respectively, while in P_1 the dry matter yield was increased by 7.9 and 6.3 percent over control in tarai and bhabar soils, respectively. The mean dry matter yield of maize also increased significantly at each successive increment of fertilizer. Substantial residual effect of previously applied P on the dry matter yield of maize was also confirmed by Tripathi et.al. (1989), Saroa et.al. (1990) and Jat and Ahlawat (2008).

CONCLUSION

The decrease in P under control and its increase at each successive higher level was highly significant. This decline under control and BUILD up under P application was not much differ between tarai and bhabar soils. The slightly more depletion was observed in available P under control and slightly less increase under P application in tarai soils than in bhabar soils. The effect of P application on dry matter yield of wheat was more pronounced at each successive level. The residual effect of P on dry matter yield of successive crop maize was also significant up to 30 mg P kg^{-1} fertilizer application.

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Table 1: Ranges and mean values of the properties of soils.

Soil properties	Tarai soils	Bhabar soils
pH	6.3-8.0 (7.3)	5.5-7.3 (6.1)
EC (dSm^{-1})	0.107-0.472 (0.308)	0.211-0.326 (0.265)
CEC (Cmol (p^+) Kg^{-1}	6.6-18.2 (13.5)	6.0-14.0 (11.6)
$CaCO_3$ (%)	0.0-1.1 (0.65)	0.3-1.4 (0.64)
Clay (%)	16.9-32.7 (25.0)	8.2-18.1 (13.8)
Silt (%)	25.4-50.1 (41.5)	19.1-47.6 (31.0)
Organic Carbon (%)	0.7.-1.87 (1.36)	0.74-2.18 (1.51)
Free Fe_2O_3 (%)	0.52-1.23 (0.77)	0.60-0.91 (0.72)
Total P (mg kg^{-1})	250-700 (500)	125-650 (450)

Values in parenthesis shows mean values of soil

Table 2: Available Phosphorous status (mg kg^{-1}) of soils after harvest of wheat and subsequent maize crops as affected by cropping and P fertilization

Soil Number	Initial available P (mg kg^{-1})	**Levels of P applied (mg kg^{-1})**									
		Wheat					**Maize**				
		P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
1	13.1	11.50	15.00	17.50	18.50	15.63	11.0	12.00	13.00	15.50	12.63
2	7.9	7.00	15.00	17.50	19.50	14.75	6.00	11.00	11.50	15.00	10.88
3	8.3	8.16	13.00	14.50	15.50	12.79	6.50	10.00	12.00	13.00	10.38
4	12.1	11.0	18.50	21.50	22.50	18.38	8.50	9.50	11.00	15.00	11.00
5	10.3	8.50	15.00	17.00	18.50	14.75	7.50	10.50	12.00	13.00	10.75
6	19.9	19.00	23.00	26.00	27.50	23.88	17.50	21.50	23.00	25.00	21.75
7	113.0	103.00	113.50	116.00	120.00	113.13	88.50	100.00	107.00	111.00	101.63
8	14.4	14.50	23.00	26.00	28.50	23.00	12.50	17.50	19.00	20.50	17.38
9	17.9	16.00	22.50	27.00	29.50	23.75	14.50	19.00	24.00	26.50	21.00
10	17.4	13.50	19.00	22.00	24.00	19.63	11.00	12.00	16.50	19.00	14.63
11	33.6	29.00	35.50	38.50	40.50	35.88	27.00	33.00	34.50	38.00	33.13
12	10.1	8.50	12.00	13.50	15.50	12.38	7.50	9.00	11.50	12.00	10.00
13	10.9	10.00	14.00	15.50	16.50	14.00	7.00	8.00	10.50	15.00	10.13
14	8.0	6.00	10.00	12.00	13.50	10.38	5.50	6.00	7.00	9.50	7.00
15	17.9	16.00	23.00	26.00	28.50	23.38	14.50	17.00	18.50	21.00	17.75
16	7.5	7.00	11.00	15.50	17.50	12.75	5.50	7.00	8.00	9.50	7.50
17	11.8	11.00	16.00	19.50	22.50	17.25	9.50	11.50	12.50	14.50	12.00
18	16.6	13.50	18.00	23.00	25.50	20.00	11.50	13.50	19.00	21.00	16.25
19	32.5	30.00	34.00	38.50	42.00	36.13	26.50	30.00	31.00	34.00	30.38
20	65.3	59.00	71.00	75.00	78.00	70.75	52.50	56.00	60.00	63.00	57.88
21	4.7	4.50	11.00	13.00	15.00	10.88	4.00	8.00	11.00	12.00	8.75
22	4.4	4.25	12.00	13.00	14.00	10.81	3.50	6.50	8.50	10.50	7.25
23	21.0	20.00	24.50	26.00	27.50	24.50	15.50	18.00	20.00	23.00	19.13
24	17.7	17.00	21.00	23.00	25.50	21.63	13.50	15.00	18.50	21.00	17.00
25	30.5	29.50	42.00	46.00	48.00	41.38	24.50	26.00	29.50	31.50	27.88
26	42.8	41.00	46.50	47.50	49.00	46.00	37.00	41.00	45.50	48.00	42.88
27	9.6	9.50	16.00	18.00	19.00	15.63	8.00	11.00	13.00	15.00	11.75
Mean	21.53	19.55	25.74	28.46	30.44	26.05	16.91	19.98	22.50	24.85	21.06
		Soil	Treatment	Soil X Treatment			Soil	Treatment	Soil X Treatment		
SEm±		0.217	0.083	0.434			0.222	0.085	0.444		
CD at 1%		0.80	0.31	1.61			0.82	0.32	1.61		
CD at 5%		0.61	0.23	1.22			0.62	0.24	1.24		

Table 3: Change in initial available P status (mg P kg^{-1}) of soil after wheat and subsequent maize crops under different levels of P application

Soil number	Levels of P applied (mg kg^{-1})							
	Wheat				Maize			
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3
1	-1.62	1.88	4.38	5.38	-2.12	-1.12	-0.12	1.11
2	-0.91	7.09	9.59	11.59	-1.91	3.09	3.59	7.09
3	-0.17	4.67	6.17	7.17	-1.83	1.67	3.67	4.67
4	-1.08	6.42	9.42	10.42	-3.58	-2.58	-1.08	2.92
5	-1.81	4.69	6.69	8.19	-2.81	0.19	1.69	2.69
6	-0.85	3.15	6.15	7.65	-2.35	1.65	3.15	5.15
7	-10.00	0.50	3.00	7.00	-24.50	-13.00	-6.00	-2.00
8	-2.89	5.61	8.61	11.11	-4.89	0.11	1.61	3.11
9	-1.91	4.59	9.09	11.59	-3.41	1.09	6.09	8.59
10	-3.91	1.59	4.59	6.59	-6.41	-5.41	-0.91	1.59
11	-4.56	1.94	4.94	6.94	-6.56	-0.56	0.94	4.44
12	-1.55	1.95	3.45	5.45	-2.55	-1.05	1.45	1.95
13	-0.94	3.07	4.57	5.57	-3.33	-2.93	-0.43	4.07
14	-2.02	1.98	3.98	5.48	-2.52	-2.02	-1.02	1.48
15	-1.93	5.06	8.06	10.56	-3.44	-0.94	0.56	3.06
16	-0.49	6.51	8.01	10.01	-1.99	-0.49	0.51	2.01
17	-0.76	4.24	7.74	10.74	-2.26	-0.26	0.74	2.74
18	-2.12	2.38	7.38	9.88	-4.12	-2.12	3.38	5.38
19	-2.49	1.51	6.01	9.51	-5.99	-2.49	-1.49	1.51
20	-6.30	5.70	9.70	12.70	-12.80	-9.30	-5.30	-2.30
21	-0.24	6.26	8.26	10.26	-0.74	3.26	6.26	7.26
22	-0.18	7.57	8.57	9.57	-0.93	2.07	4.07	6.07
23	-1.03	3.47	4.97	6.47	-5.53	-3.03	-1.03	1.97
24	-0.70	3.30	5.30	7.80	-4.20	-2.70	0.80	3.30
25	-1.01	11.49	15.49	17.49	-6.01	-4.51	-1.01	0.99
26	-1.84	3.66	4.66	6.16	-5.48	-1.84	2.66	5.16
27	-0.08	6.42	8.15	9.42	-1.58	1.42	3.42	5.42
Mean	-1.98	4.21	6.92	8.92	-4.62	-1.55	0.97	3.32

(-) sign indicates depletion of phosphorous

Table 4: Effect of phosphorous fertilizer on dry matter yield (g pot^{-1}) of wheat and successive maize crops

Soil Number	Levels of P applied (mg kg^{-1})									
	Wheat					**Maize**				
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
1	1.79	2.47	4.70	5.10	3.52	34.55	34.60	34.60	35.00	34.69
2	0.99	2.41	3.18	3.45	2.51	27.65	27.75	28.05	35.60	29.76
3	2.70	4.69	5.04	5.16	4.40	30.75	32.60	36.50	38.40	34.56
4	2.02	4.43	4.82	4.97	4.06	31.65	33.85	33.80	35.05	33.59
5	1.83	4.31	4.92	5.37	4.11	32.50	32.70	35.55	36.05	34.20
6	3.74	4.76	5.47	5.47	4.86	40.55	41.40	41.50	41.90	41.34
7	3.20	4.56	5.75	5.90	4.85	49.35	50.05	53.20	53.30	51.48
8	5.16	5.73	6.45	6.47	5.98	36.00	35.45	37.50	39.15	37.28
9	4.46	4.75	6.42	6.24	5.47	36.55	40.10	41.60	42.20	40.11
10	2.07	3.08	4.57	4.73	3.62	39.80	42.40	44.05	44.80	42.76
11	3.59	4.58	4.68	5.08	4.48	39.45	40.05	40.15	40.65	40.08
12	1.00	2.93	4.29	4.88	3.28	28.80	32.20	33.85	40.90	33.94
13	4.84	6.72	7.50	7.25	6.58	36.35	38.50	39.40	42.55	39.20
14	0.14	4.02	5.40	5.98	3.89	14.30	17.50	20.25	28.65	20.18
15	4.80	5.58	7.27	7.11	6.19	36.55	36.95	37.65	39.10	37.56
16	0.82	4.19	6.71	7.10	4.71	23.80	31.70	33.10	33.55	30.54
17	2.70	5.15	5.54	5.74	4.79	33.85	37.55	39.30	45.60	39.08
18	3.33	5.16	6.37	6.57	5.36	26.80	32.20	32.95	34.20	31.54
19	4.00	5.66	6.76	6.86	5.82	34.40	37.75	37.55	37.75	36.86
20	6.58	6.91	7.66	7.67	7.21	37.60	38.15	39.50	40.00	38.81
21	0.53	2.31	4.12	4.42	2.85	15.85	21.15	23.65	30.85	22.88
22	0.40	2.72	3.97	4.40	2.87	17.20	25.50	33.95	35.15	27.95
23	3.57	5.30	6.70	6.89	5.62	28.40	30.20	34.30	31.15	31.01
24	2.97	5.23	6.34	6.53	5.27	37.55	41.35	41.50	41.95	40.59
25	5.02	6.04	6.42	6.29	5.94	37.25	37.50	37.80	38.10	37.66
26	5.31	6.45	6.63	6.61	6.25	38.35	41.40	41.55	42.10	40.85
27	2.51	4.97	5.59	6.01	4.77	35.45	37.70	38.80	40.65	38.15
Mean	2.97	4.64	5.68	5.86	4.79	32.64	35.16	36.73	38.68	35.80
	Soil	Treatment	Soil X Treatment			Soil	Treatment	Soil X Treatment		
SEm±	0.97	0.32	0.195			0.967	0.372	1.934		
CD at 1%	0.36	0.14	0.72			3.59	1.38	(NS)		
CD at 5%	0.27	0.11	0.55			2.71	1.04	(NS)		