

# EFFECT OF CROPPING AND P FERTILIZATION ON TRANSFORMATION OF INORGANIC P FRACTIONS IN SOILS OF UTTARAKHAND

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## ABSTRACT

A pot experiment was conducted to study the effect of added P and wheat cropping on available P and inorganic P fractions in eight (five from tarai and three from bhabar) soils. Sixty four days of cropping without fertilizer depleted Olsen's P by 4.6 and 1.2 mg kg<sup>-1</sup>, while its amount increased by 8.5 and 6.8 mg kg<sup>-1</sup> in tarai and bhabar soils, respectively, at 30 mg P kg<sup>-1</sup> level. Soils low in available P also had much lower Saloid-P. All the active inorganic P fractions got depleted due to cropping without fertilizer, while their contents increased after the wheat crop with the addition of P fertilizer @ 10, 20 and 30 mg P kg<sup>-1</sup> soil. The magnitude of these changes was largest in Ca-P while the relative change, as per cent of initial, was largest in Saloid-P fraction. Regression analysis indicated that crops utilized more of Saloid-P and Al-P in these Ca-P dominant soils.

**Key words:** Inorganic P fractions, available P, tarai soils. bhabar soils. wheat

## INTRODUCTION

Compared with other nutrients, P is the least mobile and least available for plants in soil. Therefore, P is greatly affected by fertilization. Phosphorous fractionation schemes have been used to evaluate the effects and relationship between the P fraction and the P that is available for plants. The low response of crop P may be due to transformation of added phosphorus into different products with lower availability. Li et al (2015) found that fertilization significantly increased the accumulation of extractable inorganic P fractions. The fertilizer phosphorous use efficiency (PUE) in most of the experiments has been reported to be in between 10 to 30 per cent (Datta et al., 1970). Among the inorganic forms, Saloid-P, Al-P, Fe-P and Ca-P are considered important forms from a plant availability point of view. Although the P fractions differ in their behaviour and fate in soils. Therefore, the knowledge of changes in these forms of phosphorus present in soil is useful in assessing the availability of phosphorus to crops. The present investigation was carried out with a view to study the changes in the inorganic soil P fractions and P availability as affected by cropping and P fertilization.

## MATERIALS AND METHODS

Bulk surface (0 - 0.15 m) soil samples varying in texture, pH and organic carbon were collected from eight sites of tarai (serial number 1 to 5) and bhabar (serial no. 6 to 8) 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-HClO<sub>4</sub>, methods were used.

Wheat (cv. UP 2338) was sown in plastic pots containing 4.5 kg of soil, and thinned after 10 days to maintain four plants in each pot. The treatments included 10 (P<sub>1</sub>), 20 (P<sub>2</sub>) and 30 (P<sub>3</sub>) mg P kg soil, respectively, applied through single super phosphate, and a P control (P<sub>0</sub>), all replicated twice in the completely randomized design. Each pot was supplied with 60 mg N kg<sup>-1</sup> and 16.6 mg K kg<sup>-1</sup> soil. At 64 days, plants were harvested, washed with deionized water, oven dried and weighed. Phosphorus content in plants was determined by the vanadomolybdate yellow colour method. The fractions of soil inorganic P were determined by the Peterson and Corey (1966) method. Available P was extracted by the NaHCO<sub>3</sub> solution (Olsen et al. 1954) and the concentration of P was determined by the Murphy and Riley (1962) method.

## RESULTS AND DISCUSSION

A depletion in the initial content of available P during 64 d wheat cropping without fertilizer (at P<sub>0</sub>) was evident in all the soils studied (Table 2), the magnitude being smaller in the soils with low initial content and vice versa. Depletion expressed as percent of the initial content. However, did not follow this trend. On the other hand, wheat cropping with the addition of P right from the lower dose (P<sub>1</sub>) through the highest (P<sub>3</sub>) increased the available P content in soil. Percent wise, under all the levels of applied P the increase was comparatively higher in the soils of initially poorer P status (nos. 3, 5 and 7) than those richer in available P. Such depletion of available P under P control and its build up at higher rates of P application under cropping was also reported by Chhabra (1985) and Sagger et al., (1986).

The Ca-P was the dominant inorganic P fraction, followed by either Al-P or Fe P (Table 3). It is obvious as these soils are derived from calcareous alluvium from lower Siwaliks and are quite young (Deshpande et al. 1971). Such dominance of Ca-P was also reported earlier in the soils of the tarai-bhabar tract (Dixit 1992). Abolfazli et al (2012) showed that Ca-P was the predominant form of inorganic P in calcareous soil. Tarai soils, in general, were slightly richer in Ca-P and Al-P than the Bhabar soils (Table 3). Soils low in available P had much less Saloid-P and also less Al-P than the soils with higher content of available P. It can be understood in the light of good relationships of Olsen-P with Saloid-P and Al-P as reported by Singh and Omanwar (1987).

The contents of various P fractions in soil as affected by 64 d wheat cropping with P control and the highest level of P (Table 4) revealed a depletion of 1.0 to 1.3 mg kg<sup>-1</sup> in Saloid-P without fertilizer (P<sub>0</sub>), excepting two soils of tarai (nos. 3 and 5) which had its much lower initial content. Interestingly, both the soils recorded much less P uptake (less than 1 mg pot<sup>-1</sup>) as against the mean of P uptake (about 11 mg pot<sup>-1</sup>) under P<sub>0</sub>. Magnitude wise, the decrease in P fractions under P<sub>0</sub> followed the order Ca-P>Al-P>Fe-P>Saloid-P, as was the order of their relative abundance. However, as per cent of initial content, a greater proportion of Saloid-P and Al-P were depleted to their amounts initially present.

There was an increase in each P fraction from the initial content under wheat cropping with the addition of P right from 10 mg P kg<sup>-1</sup> (P<sub>1</sub>) through P<sub>3</sub>. The magnitude of mean build up was maximum in Ca-P. However, on a per cent basis the order was Saloid-P>Fe-P>Al-P>Ca-P. Among the P fractions studied, the Saloid-P had the greatest relative variation (per cent basis) both due to short time wheat cropping without fertilizer as well as with high dose of P as it represents loosely bound or approximately the water-soluble P. These changes were relatively more in bhabar soils than in tarai soils because of presumably lower buffering of Bhabar soils owing to their relatively lower clay content (Table 1). A remarkably high increase in Saloid-P (even greater than in Al-P) at higher levels of P application strongly indicates the virtual absence of P fixation in these soils, at least in a short period of two months. An increase in Saloid-P in soil during two months of maize cropping was reported by Bahl and Avtar Singh (1997). Jain and Sarkar (1979) attributed the increase in Saloid-P in soil in the presence of actively growing wheat, to an interconversion from Fe-P and Al-P fractions.

Stepwise regression analysis (Table 5) revealed that Saloid-P together with Al-P explained significant (93%) variation in the dry matter yield of wheat. The Saloid-P alone could explain 76% variation in the P uptake. The above results further strengthen the involvement of Saloid-P and Al-P in the availability of soil P to wheat and in the crop yield.

## Conclusion

Soils low in available P were also low in Saloid-P. All the inorganic fractions were depleted due to cropping without fertilizer, while their contents increased after the wheat crop with the addition of P fertilizer. magnitude wise, decreased in P fractions under control followed the order Ca-P>Al-P>Fe-P>Saloid-P. The magnitude of mean build up was maximum in Ca-P, however, on percent basis the order was Saloid-P>Fe-P>Al-P> Ca-P. These changes were relatively more in bhabar soils than in tarai soils. The wheat crop utilized more Saloid-P and Al-P than the Ca-P.

## REFERENCES

- Abolfazli, F, Forghani, A. and Norouzi, M. 2012. Effects of phosphorous and organic fertilizers on phosphorous fractions in submerged soil. *J. Soil Sci. Plant Nutr.*, 12: 349-362
- Bahl, G. S. and Avtar Singh 1997. The inorganic soil phosphorous fractions and available P as influenced by green manuring, cropping and P fertilization. *J Indian Soc. Soil Sci.* , 45: 19.
- Chhabra, R. 1985. Crop responses to phosphorus and potassium fertilization of a sodic soil. *Agronomy J.*, 77: 699-702.
- Datta, N. P., Venkateshwarlu, J., Kamath, M. B. and Khanna, P. K. (1970) Technology, Sindri, 7, 19.
- Deshpande, S. B., Fehrenbacher, J. B. and Ray, B. W. 1971. Mollisols of tarai region of Uttar Pradesh, Northern India. II Genesis and classification. *Geoderma*, 6 : 195-201.
- Dixit, A. K. 1992. Chemo-edaphological characterization of Bhabar-Tarai-plain transect soils of Ramganga-Kosi interbasin. Ph. D. thesis, G. B. Pant Univ. Agric. & Tech., Pantnagar, U.P.
- Jain, J. M. and Sarkar, M. C. 1979. *Bull. Indian Soc. Soil Sci.* ,12: 460.
- Li, Y., Yang, R., Gao, R., Wei, H., Chen, A. and Li, Y. 2015. Effects of long-term phosphorous fertilization and straw incorporation on phosphorous fractions in subtropical paddy soil. *J. Integr. Agr.*, 14: 365-373.
- Murphy, J. and Riley, J. P. 1962. A modified single method for the determination of phosphates in natural waters. *Anal. Chim. Acta.* 27 : 31-36.
- Olsen, S. R. Cole, C. V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *Circ. U. S. Dep. Agric.* 939.
- Peterson, G. W. and Corey, R. B. 1966. A modified Chang and Jackson procedure for routine fractionation of inorganic soil phosphates. *Soil Sci. Soc. Am. J.* 30: 563-565.
- Sagger, S., Dev, G. and Meelu, O. P. 1986. Available soil phosphorus in a rice-wheat rotation after extended super phosphate application. *IRRNL*, 11: 26-27.
- Singh, R. and Omanwar, P. K. 1987. Phosphorus forms in some soils of mid-western Uttar Pradesh II. Soil available phosphorus. *J. Indian Soc. Soil Sci.* 35: 642-646.

**Table 1.** Important characteristics of the soils used.

Soil Number and location	pH	EC (dSm <sup>-1</sup> )	CEC Cmol (p <sup>+</sup> ) kg <sup>-1</sup>	Clay (%)	CaCO <sub>3</sub> (g kg <sup>-1</sup> )	Organic carbon (g kg <sup>-1</sup> )	Fe <sub>2</sub> O <sub>3</sub> (g kg <sup>-1</sup> )	Texture
Tarai soils								
1. Devaria	7.6	0.731	6.6	19.2	6.0	108	7.0	L
2. CRC E <sub>3</sub> Block	8.2	0.396	18.2	28.1	12.0	17.0	13.0	CL
3. Patharchatta	7.8	0.326	16.0	29.2	16.0	16.4	6.3	CL
4. CRC G <sub>2</sub> block	7.1	0.225	10.7	24.2	6.0	11.4	10.0	L
5. PCP D <sub>2</sub> block	7.9	0.317	16.1	32.7	16.0	12.1	7.6	SiCL
Bhabar soils								
6. Chandanichauk	5.8	0.326	13.9	14.5	5.0	21.8	8.1	SL
7. Kusun khera	5.8	0.253	14.0	12.4	6.0	18.8	9.1	SL
8. Shafi farm	6.5	0.211	6.0	8.2	4.0	7.4	6.0	SL

L= Loam, CL = Clay loam, SiCL = Silty clay loam, SL = sandy loam

**Table 2:** Effect of wheat cropping and different levels of P application on the change in available (Olsen's) P content (mg kg<sup>-1</sup>) in soils

Soil number	Initial available P (mg kg <sup>-1</sup> )	Change under P level			
		P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>
Tarai soils					
1.	113.0	-10.0 (-8.8)	0.5 (0.4)	3.0 (2.7)	7.0 (6.2)
2.	33.6	-4.6 (-13.7)	1.9 (5.6)	4.9 (14.6)	6.9 (20.5)
3.	8.0	-2.0 (-25.0)	2.0 (25.0)	4.0 (50.0)	5.5 (68.8)
4.	65.3	-6.3 (-9.6)	5.7 (8.7)	9.7 (14.9)	12.7 (19.4)
5.	4.7	-0.2 (-4.2)	6.3 (134.0)	8.3 (176.6)	10.3 (219.1)
Bhabar soils					
6.	21.0	-1.0 (-4.8)	3.5 (16.7)	5.0 (23.8)	6.5 (31.0)
7.	17.7	-0.7 (-4.0)	3.3 (18.8)	5.3 (29.9)	7.8 (44.1)
8.	42.8	-1.8 (-4.2)	3.7 (8.6)	4.7 (11.0)	6.2 (14.4)

Figures in the parenthesis denote percent change from the initial content

**Table 3:** Initial contents of inorganic P fractions (mg kg<sup>-1</sup>) in the experimental soils

Soil no.	Inorganic P Fractions				
	Saliod -P	Al-P	Fe-P	Ca-P	Total P
<b>Tarai soils</b>					
1.	10.0 (2.2)	45.0 (10.0)	30.0 (6.7)	142.5 (31.6)	450
2.	7.5 (1.2)	40.0 (6.4)	35.0 (5.6)	270.0 (43.3)	625
3.	1.3 (0.2)	27.5 (4.8)	31.3 (5.4)	257.0 (44.7)	575
4.	15.0 (2.1)	50.0 (7.1)	22.5 (3.2)	300.0 (42.9)	700
5.	1.3 (0.3)	30.0 (6.7)	16.3 (3.6)	200.0 (44.4)	450
<b>Bhabar soils</b>					
6.	6.3 (1.0)	35.0 (5.4)	40.0 (6.2)	250.0 (38.5)	650
7.	2.5 (0.6)	20.0 (4.7)	18.8 (4.4)	125.0 (29.4)	425
8.	5.0 (1.1)	25.0 (5.3)	31.3 (6.6)	180.0 (37.5)	475

Figures in the parenthesis are expressed as per cent of the total P

**Table 4:** Change in the contents of inorganic P fractions. (mg kg<sup>-1</sup>) and P uptake (mg pot<sup>-1</sup>) by wheat cropping without fertilizer (P<sub>0</sub>) and with 30 mg P kg<sup>-1</sup> (P<sub>3</sub>) dose.

Soil number	P fractions									
	Saliod- P		Al-P		Fe-P		Ca-P		P uptake	
	P <sub>0</sub>	P <sub>3</sub>								
<b>Tarai soils</b>										
1.	-1.2 (-12.0)	2.5 (25.0)	-2.5 (-5.5)	2.5 (5.5)	-2.5 (-8.3)	2.5 (8.3)	-25.0 (-17.5)	7.5 (5.3)	18.10	37.92
2.	-1.2 (-16.0)	5.0 (66.6)	-5.0 (-12.5)	2.5 (6.3)	-2.5 (-7.1)	11.3 (32.1)	-5.0 (-1.9)	2.5 (0.9)	13.54	20.98
3.	0.0 (0.0)	2.5 (192.3)	-2.5 (-9.1)	2.5 (9.1)	-5.0 (-16.0)	3.7 (11.8)	-4.0 (-1.6)	5.5 (2.1)	0.32	16.68
4.	-1.2 (-8.0)	3.8 (25.3)	-2.5 (-5.0)	2.5 (5.0)	-2.5 (-11.1)	5.0 (22.2)	-30.0 (-10.0)	7.5 (2.5)	22.39	32.23
5.	0.0 (0.0)	2.5 (192.3)	-5.0 (-16.7)	2.5 (8.3)	-2.5 (-15.3)	1.2 (7.4)	-12.5 (-6.3)	5.0 (2.5)	0.91	14.19
<b>Bhabar soils</b>										
6.	-1.3 (-20.6)	3.7 (58.7)	-2.5 (-7.1)	2.5 (7.1)	-2.5 (-6.3)	1.3 (3.3)	-20.0 (-8.0)	12.5 (5.0)	8.49	18.92
7.	-1.2 (-48.0)	0.6 (24.0)	-2.5 (-12.5)	0.0 (0.0)	-1.3 (-6.9)	7.5 (39.9)	-7.5 (-6.0)	5.0 (4.0)	7.28	18.94
8.	-1.0 (-20.0)	6.3 (126.0)	-5.0 (-20.0)	2.0 (10.0)	-2.5 (-8.0)	1.2 (3.8)	-5.0 (-2.8)	2.5 (1.4)	16.93	23.35

Figures in the parenthesis indicate corresponding percent change with respect to initial content

**Table 5.** Stepwise regression between dry matter yield and P uptake by wheat and P fractions

Yield = 3.183 + 0.203 Saloid-P	R <sup>2</sup> 0.49
Yield = 8.203 + 0.572 Saloid-P - 0.190 AI-P	0.93**
Yield = 7.671 + 0.591 Saloid-P - 0.211 AI-P + 0.005 Ca-P	0.96**
Yield = 7.289 + 0.590 Saloid-P - 0.211 AI-P + 0.004 Ca-P + 0.205 Fe-P	0.97**
P uptake = 0.864 + 0.152 Saloid-P	0.76**
P uptake = 1.881 + 0.180 Saloid-P - 0.005 Ca-P	0.91**
P uptake = 1.582 + 0.179 Saloid-P - 0.006 Ca-P + 0.002 Fe-P	0.93**