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Chaurya Jagrutiben R
Department of Soil Science & Agriculture Chemistry, Junagadh Agriculture, University, Junagadh, Gujarat, India

AV Rajani
Department of Soil Science & Agriculture Chemistry, Junagadh Agriculture, University, Junagadh, Gujarat, India

Corresponding Author:
Chaurya Jagrutiben R
Department of Soil Science & Agriculture Chemistry, Junagadh Agriculture, University, Junagadh, Gujarat, India

Consequence of long-term balance nutrient management on soil phosphorus dynamics in a calcareous clay under Aicrp-ltfe soils

Chaurya Jagrutiben R and AV Rajani

Abstract
The application of FYM also maintained or increased phosphorus status of LTFE soils. In treatments of FYM (T_8, T_9), the status of phosphorus fractions increased. Available-P status of LTFE soil at Initial stage was low in category (< 28 Kg P_2O_5 ha^{-1}) in most of the treatments, after long run (20^{th} year) it was more decreased except in treatments which were received FYM (T_8 & T_9). Due to application of FYM available status of P_2O_5 in LTFE soil increased up to medium category (28-56 Kg P_2O_5 ha^{-1}) from low category. There were overall increased in Inorganic-P & Total-P status of LTFE soils, but status of Available-P was decreased, which might be due to calcareousness of soil, which fixed phosphorus that applied as a fertilizers and transformed it in unavailable form to the plant, because of this reaction, available status of LTFE soil decreased, except in treatments where application of FYM, full dose of P and biofertilizer were there due to chelating effect of organic material and solubilizing reaction of microorganisms which protect available-P form to fixed in unavailable form.

Keywords: Phosphorus fraction, total phosphorus

Introduction
Phosphorus is essential nutrient for the plant growth. The importance of phosphorus in conservation of soil fertility and improving crop productivity is well recognized in Indian soils, most of which are either deficient or marginal in P status. Soils are also known to vary widely in their capacity to supply phosphorus to plants. Only a small fraction of total P in soil is found in plant available form. Their bioavailability in the soil is ruled by several factors like, soil pH, texture, moisture, lime content, applied nutrients, *etc.* Besides this, the fact that the forms in which these nutrients, particularly phosphorus exists in the soil, is also a factor which contributes the obstacle in the mode of its availability.
The knowledge of the various forms of phosphorus present in a soil and condition under which these became available to the plants is a criterion in assessing the availability of phosphorus in the soil and crop response to applied P Fertilizers (Kothandaraman and Krishnamoorthy, 1979) [8]. Since the different forms of soil phosphorus have different solubility under different soils environmental conditions; the availability in the soil and the uptake of phosphorus by crops should largely depend upon the different factors usual in and through the soils (Narayanasamy and Biswas, 2000) [10]. Thus, knowledge of the dynamics of P in soil is helpful in understanding the soil processes influencing the availability of this nutrient and its uptake by plant.

Materials and Method
Surface soil samples (0-15 cm) were collected from the AICRP-LTFE soils conducted on groundnut-wheat sequence in Randomized Block Design replicated four times at Instructional Farm Junagadh Agricultural University, Junagadh during the year 1999-2000 (1^{st} year, after wheat), 2008-09 (10^{th} year, after wheat) and 2018-19 (20^{th} year, after wheat). The treatments were T_1- 50% NPK of recommended doses in Groundnut-Wheat sequence, T_2- 100% NPK of recommended doses in Groundnut -Wheat sequence, T_3 -150% NPK of recommended doses in Groundnut-Wheat sequence, T_4 - 100% NPK of recommended doses in Groundnut-Wheat sequence + $ZnSO_4$ @ 50 kg ha^{-1} once in three year to Groundnut only (i.e. '99, 02, 05, … etc.), T_5 - NPK as per soil test, T_6 - 100% NP of recommended doses in Groundnut -Wheat sequence, T_7 - 100% N of recommended doses in Groundnut -Wheat sequence, T_8 - 50% NPK of recommended doses + FYM @ 10 t ha^{-1} to Groundnut and 100% NPK to Wheat, T_9 – Only

FYM @10 t ha^{-1} to Groundnut and @ 15 t ha^{-1} to Wheat., T_{10} - 50% NPK of recommended doses in Groundnut -Wheat sequence + *Rhizobium* + PSM to Groundnut and 100% NPK to Wheat, T_{11} - 100% NPK of recommended doses in Groundnut -Wheat sequence (P as SSP) and T_{12} – Control. These soil samples were analyzed to determine the different forms of Phosphorus on the basis of method mentioned below.

a. **Total Phosphorus:** The Total-P was determined by digesting 0.1 g, of 0.15 mm sieved, oven dried soil with HNO_3 and $HClO_4$ acids and then followed vanadomolybdate method (Hesse, 1971) [4].
b. **Total inorganic phosphorus:** The Inorganic-P was extracted with Concentrated HCl (Hesse, 1971) [4] and the P in solution was determined with chlorostannous reduced molybdophosphoric blue color method in HCl system (Jackson, 1973) [5].
c. **Organic phosphorus:** The difference between total and Inorganic-P was reported as Organic-P.
d. **Fractions of the inorganic phosphorus:** The fractions of the Inorganic-P, which includes Saloid Bound-P, Al-P, Fe-P, Reductant Soluble-P, Occluded-P and Calcium-P was extracted successively by the method of Chang and Jackson (Peterson and Corey, 1966) [11] and the blue color was also developed as detailed by them.

All the colorimetric reading was recorded on double beam spectrophotometer.

***Depletion (%):** These nutrients depleted from soil by different cycles were calculated by the formula:

$$\text{Depletion of Nutrient (\%)} = \frac{\left\{\begin{matrix}\text{Nutrient status}\\ \text{of index year}\end{matrix}\right\} - \left\{\begin{matrix}\text{Nutrient status}\\ \text{of final year}\end{matrix}\right\}}{\text{Nutrient status of index year}} \text{ X } 100$$

Result and Discussion

The results obtained from the present investigation have been discussed below.

1. Total phosphorus: The data presented in table 1 revealed that the status of Total Pat initial stage, after 10th and 20th year of experiment was significantly affected due to various treatments, but it was found non-significant due to treatments when pooled over years.1st year of experiment, the highest value was recorded in T_7 & after 10th year it was recorded in T_8 (50% NPK + FYM @ 10 t ha^{-1} to G'nut & 100% NPK to wheat). The results are supported by earlier works of Rajani *et al*., (2010) [13] investigated that application of FYM was there *i. e*. in treatments T_8 and T_9 there was increase in the availability of phosphorus after long run in the LTFE soils. There was overall increase in Total-P status. Rahate *et al.*, (1979) [12] also that buildup of total P was significant when P fertilizers were applied along with FYM. The Y x T interaction was also significant. There was overall increase in the status of Total-P after ten years as compared to first year, but marginally overall P status decreased after 20th year as compared to 10th year and Y x T interaction was found significant.

Table 1: Status of different forms of phosphorus in soils of LTFE in 1st, 10th and 20th year

Treat.	Total-P (ppm)				Inorganic-P (ppm)			
	1st year	10th year	20th year	Pooled	1st year	10th year	20th year	Pooled
T_1	924.14	2473.72	1906.18	1768.01	551.50	888.94	1561.76	1000.73
T_2	922.00	4035.25	2250.00	2402.42	543.69	1192.75	611.03	782.49
T_3	907.13	2693.06	2716.81	2105.67	597.32	920.65	1083.03	867.00
T_4	734.00	3086.81	1985.56	1935.46	493.18	1004.25	1029.45	842.29
T_5	724.50	2225.63	3172.00	2040.71	528.14	838.15	1232.96	866.42
T_6	882.00	1857.94	2992.31	1910.75	521.40	958.04	1248.75	909.40
T_7	1383.69	1303.13	878.75	1188.52	514.92	656.88	499.78	557.19
T_8	1007.00	4041.00	1342.25	2130.08	532.40	1051.99	1054.25	879.55
T_9	867.06	2173.30	2445.88	1828.75	558.65	984.94	1283.01	942.20
T_{10}	1125.00	2623.00	2335.25	2027.75	536.81	871.02	668.22	692.02
T_{11}	875.25	3072.75	1499.00	1815.67	562.91	798.57	979.51	780.33
T_{12}	928.25	2361.38	1995.13	1761.59	563.26	542.63	739.50	615.13
Mean	940.00	2662.25	2126.59	1909.61	542.01	892.40	999.27	811.23
S.Em.±	26.86	54.20	38.38	23.88	20.41	21.02	21.92	12.20
C.D. at 5%	77.28	155.95	110.42	NS	NS	60.48	63.08	NS
C.V. %	5.71	4.07	3.61	4.33	7.53	4.71	4.39	5.21
Y * T	S.Em.± 40.69		C.D. at 5% 114.17		S.Em.± 19.80		C.D. at 5% 55.55	

2. Inorganic Phosphorus: Inorganic fraction of phosphorus in LTFE soils was significantly affected due to various treatments after 10th & 20th year (Table 1). After 10th years of cropping sequence, it showed significantly higher value in treatment T_2 and it was significantly higher than all other treatments. Whereas after 20th years of cropping sequence significantly the highest value was recorded in treatment T_1 and it was significantly higher than all other treatments where as it found non-significant when pooled over years. The overall inorganic forms of phosphorus increased after the span of 20 years as compare to 1styear. The results are supported by earlier works of Rajani *et al*., (2010) [13] found that application of FYM was there *i. e*. in treatments T_8 and T_9 there was increase in the availability of phosphorus after long run in the LTFE soils. There was overall increase in Inorganic-P status. Similar result was reported by Gupta *et al.*, (1999) [3] who reported that application of P alone and in combination with FYM increased the contents of total P and different P fractions. The Y x T interaction was also significant.

3. Organic Phosphorus: At 1st year of the experiment, the status of the Organic-P was significantly higher in plot of T_7, but it was the significantly highest in plot of T_8 & T_5 after 10 & 20 year of experiment (Table 2), respectively. When pooled

over years, it was found non-significant. The Y x T interaction was also significant. There was overall increased in Organic-P status of the soil after 20 year of experiment as compared to 1st year, it might be due to addition of organic matter through crop residue. Gupta *et al.,* (1999) [3] investigated that application of P alone and in combination with FYM increased the contents of different P fractions.

Table 2: Status of different forms of phosphorus in soils of LTFE in 1st, 10th and 20th year

Treat.	Organic-P (ppm)				Saloid bound-P (ppm)			
	1st year	10th year	20th year	Pooled	1st year	10th year	20th year	Pooled
T_1	372.64	1584.78	344.18	767.20	6.94	17.54	5.00	9.83
T_2	378.31	2842.50	1639.00	1619.94	4.56	26.41	12.85	14.61
T_3	309.81	1772.41	1633.81	1238.68	3.96	33.90	7.76	15.21
T_4	240.82	2082.56	956.56	1093.32	9.14	18.51	10.11	12.59
T_5	196.36	1387.48	1939.00	1174.28	1.95	25.69	6.37	11.34
T_6	360.60	899.90	1743.31	1001.27	1.90	34.45	20.05	18.80
T_7	868.77	646.24	378.75	631.25	4.59	18.40	9.01	10.67
T_8	474.60	2989.01	288.00	1250.54	3.97	34.45	98.51	45.64
T_9	308.41	1188.36	1162.88	886.55	4.21	33.94	121.06	53.07
T_{10}	588.19	1751.98	1667.25	1335.81	2.36	24.37	26.73	17.82
T_{11}	312.34	2274.18	519.00	1035.17	3.58	15.86	4.66	8.04
T_{12}	364.99	1818.75	1255.13	1146.29	3.99	18.05	4.05	8.70
Mean	397.99	1769.85	1127.24	1098.36	4.26	25.13	27.18	18.86
S.Em.±	32.57	57.27	40.95	25.86	0.12	1.18	0.76	0.47
C.D. at 5%	93.71	164.79	117.83	NS	0.34	3.39	2.18	NS
C.V. %	16.37	6.47	7.27	8.16	5.53	9.38	5.59	8.61
Y * T	S.Em.± 44.60		C.D. at 5% 125.15		S.Em.± 0.81		C.D. at 5% 2.28	

4. Saloid Bound-P: The data presented in table 2 indicated that at 1st, 10th & 20th year of investigation, Saloid bound P content of soil varied significantly under various treatment combinations. At 1st it was recorded highest in treatment T_4, but found highest in T_8 & T_9 after 10 & 20 years of experiment, respectively. When pooled over years it was non-significant and Y x T interaction was significant. Overall Status of this form of P increased up to 10 year and then it remained stable. The results are supported by earlier works of Mitran *et al*., (2016) [9] investigated that application of inorganic fertilizer N (50%) with organics, however, caused increase in almost all the P fractions in soil over the control. Gupta *et al.,* (1999) [3] also similar trend that application of P alone and in combination with FYM increased the contents of different P fractions.

5. Aluminum-P: At 1st year of the experiment, Al-P status of soil differed significantly and the highest value (8.45 ppm) of Al-P was recorded in the soils which received 50% N P K doses of recommended to G'nut-Wheat sequence (T_1) (Table 3). After 10th& 20th years of experiment, it was also significantly affected by various treatment combinations. The highest value (7.74 ppm) was recorded in T_{11} at10th year and 8.75 ppm in T_8 at 20th year. The results are supported by earlier works of Amruth *et al.,* (2017) [1] who reported that amount of AL-P significantly higher for all inorganic and organic forms of P in soil were recorded in application of higher dose of P. Sihag *et al.,* (2005) [16] also recorded similar results the amount of P recovered in Al-P form increased significantly with the application of inorganic fertilizers and their combined use with organic materials over control. When pooled over years, it was non-significant, but Y x T interaction was found significant. There was overall decreased in Al-P status of LTFE soils after a span of 20 years, it might be due to inter-conversion of Al-P to other fractions like Saloid-P & Reductant-P, which were increased after a span of 20 years due to calcareousness of LTFE soils.

Table 3: Status of different forms of phosphorus in soils of LTFE in 1st, 10th and 20th year

Treat.	AL-P (ppm)				Fe-P (ppm)			
	1st year	10th year	20th year	Pooled	1st year	10th year	20th year	Pooled
T_1	8.45	2.12	7.02	5.86	83.89	9.49	4.98	32.79
T_2	7.51	5.79	3.66	5.65	74.74	4.75	7.72	29.07
T_3	3.19	7.18	7.34	5.90	57.83	10.02	17.78	28.54
T_4	6.14	2.06	2.66	3.62	113.80	9.23	12.96	45.33
T_5	6.98	3.44	2.47	4.29	100.48	16.12	5.72	40.77
T_6	5.54	3.38	2.98	3.97	67.49	10.54	16.34	31.45
T_7	3.94	4.63	1.17	3.25	91.64	10.49	4.96	35.69
T_8	5.85	6.53	8.75	7.04	54.91	6.55	3.43	21.63
T_9	3.68	4.11	4.41	4.07	82.13	3.31	5.43	30.29
T_{10}	5.45	3.76	2.56	3.92	73.69	5.39	5.54	28.20
T_{11}	4.65	7.74	2.76	5.05	103.38	14.54	4.88	40.93
T_{12}	4.24	5.58	2.73	4.18	92.44	14.63	9.64	38.90
Mean	5.47	4.69	4.04	4.73	83.03	9.59	8.28	33.63
S.Em.±	0.12	0.17	0.15	0.08	3.77	0.24	0.65	1.28

C.D. at 5%	0.34	0.48	0.43	NS	10.84	0.68	1.87	NS
C.V. %	4.31	7.10	7.33	6.15	9.07	4.92	15.69	13.15
Y * T	S.Em.± 0.15		C.D. at 5% 0.41		S.Em.± 2.21		C.D. at 5% 6.21	

6. Fe-P: Iron bound P was significantly affected by treatments of 10th year & 20th year (Table 3). 1st year also significantly differ in Fe-P, but it was not affected by treatments when pooled over years. The Y x T interaction was found non-significant. At 1st year, the highest value was recorded in plot of T_4, followed by T_{11}, T_5, T_{12}, and T_7, 10th year it was the highest in T_5 (NPK as per soil test) followed by T_{12}, T_{11}, T_6, T_7, T_3 & T_1 and 20th year it was the highest in T_3 (150% NPK) followed by T_6, T_4 , T_{12}& T_2 . There was much decrease in overall status of Fe-P 10th & 20th years as compared to 1st year of the experimental field. The results are supported by Venugopal *et al.,* (2017) [19] investigated that application of NPK (Zn) caused decrease in the P fraction. Similar result was also reported by Setia and Sharma (2007) [15] who reported that the N (120 and 180 Kg ha^{-1}) and K (0 and 33.2 Kg ha^{-1}) application caused decrease in the P fraction. The overall decreased in status of Fe-P after a span of 20 years, seems to be inter conversion of Fe-P to other forms like Saloid-P & Reductant Soluble-P due to calcareousness of LTFE soils.

7. Reductant Soluble-P: The data presented in table 4 depicted that overall increase in soil status of Reductant Soluble P in 10th & 20th year and it was also significantly affected by treatment combination, but it was not affected due to treatments when pooled over years. After 1st year soil content of Reductant-P was the highest in T_6, after 10th year it was in T_{11} and after 20th year was in T_9 (Only FYM @ 10 t ha^{-1} to G'nut and 15 t ha^{-1} to Wheat). The results were supported by earlier works of Mitran *et al.,* (2016) [9] reported that application of 50% NPK apply with 50% FYM is significantly affected Reductant Soluble-P. Similar trend was reported by Sihag *et al.,* (2005) [16] that the highest amount of all the forms of P was recorded under farm yard manure. The Y x T interaction was also found significant.

Table 4: Status of different forms of phosphorus in soils of LTFE in 1st, 10th and 20th year

Treat.	Reductant soluble-P (ppm)				Occluded-P (ppm)			
	1st year	10th year	20th year	Pooled	1st year	10th year	20th year	Pooled
T_1	79.54	89.75	462.67	210.65	8.83	2.41	6.19	5.81
T_2	79.79	141.04	273.75	164.86	3.23	5.05	23.12	10.46
T_3	74.25	196.23	183.52	151.33	5.03	2.31	13.81	7.05
T_4	87.75	183.06	221.81	164.21	5.64	3.40	18.65	9.23
T_5	84.25	156.13	301.75	180.71	5.68	6.82	5.95	6.15
T_6	105.00	101.56	256.98	154.51	4.07	2.32	23.26	9.88
T_7	93.04	61.79	214.71	123.18	5.06	3.54	19.76	9.45
T_8	79.58	187.19	369.06	211.94	5.49	1.06	8.91	5.15
T_9	78.67	156.17	473.25	236.03	4.17	9.23	25.29	12.90
T_{10}	83.92	140.06	217.77	147.25	4.18	2.43	16.09	7.57
T_{11}	86.17	197.31	193.56	159.01	7.76	2.61	8.71	6.36
T_{12}	84.63	126.50	318.17	176.43	5.54	2.35	8.70	5.53
Mean	84.72	144.73	290.58	173.34	5.39	3.63	14.87	7.96
S.Em.±	1.98	9.35	22.82	8.25	0.44	0.20	0.79	0.31
C.D. at 5%	5.69	26.91	65.66	NS	1.28	0.57	2.29	NS
C.V. %	4.67	12.93	15.71	16.48	16.47	10.92	10.69	13.51
Y * T	S.Em.± 14.29		C.D. at 5% 40.09		S.Em.± 0.54		C.D. at 5% 1.51	

8. Occluded-P: Occluded-P status of LTFE soils was affected significantly by treatments. The 1st year also showed significant difference, but was found non-significant when pooled over years (Table 4). At 1st year of experimentation, the significantly highest value of Occluded-P was recorded in soils which received 50% N P K doses of recommended to G'nut-Wheat sequence (T_1), Whereas significantly the highest value was recorded in T_9 (10 t FYM ha^{-1} to G'nut and 15 t ha^{-1} to wheat only) after 10th & 20th year completion of experiment. The results are supported by Venugopal *et al.* (2017) [19] who reported that Occluded P increased significantly with application of Organic matter. Similar trend was also reported by Sihag *et al.,* (2005) [16]. The highest amount of all the forms of P was recorded under farm yard manure. The Y x T interaction was significant. Overall decrease in status of Occluded P was recorded after 10th years, but after that it was increased.

9. Calcium-P: The data presented in table 5 revealed that content of Ca-P in LTFE soils was significantly affected by application of various levels of NPK fertilizers and other combination of biological materials. It was also significantly differed at 1st year of experiment, but it was found non-significant when pooled over years. 1th year G'nut-wheat cropping sequence, Ca-P status of soil was found significantly higher in treatment, which received 100% N P of recommended doses in G'nut -Wheat sequence (T_6), whereas it was significantly higher in treatment which received only 50% NPK of R.D.F. + 10 t ha^{-1} FYM to G'nut and 100% NPK to wheat (T_8) in case of 10th year G'nut-wheat cropping sequence. The results are supported by earlier works of Mitran *et al.,* (2016) [9] who reported the addition of organic residue with inorganic fertilizer the increase of Ca-p when 50% NPK apply with 50% FYM. Sihag *et al.,* (2005) [16] also reported that the amount of P recovered in Ca-P form increased significantly with the application of inorganic fertilizers and their combined use with organic materials over control. After 20th year it was also affected significantly due to treatments. The Y x T interaction also showed significant variation in Ca-P content of the LTFE soils.

Table 5: Status of different forms of phosphorus) in soils of LTFE in 1st, 10th and 20th year

Treat.	Ca-P (ppm)				Available P_2O_5 (kg ha^{-1})			
	1st year	10th year	20th year	Pooled	1st year	10th year	20th year	Pooled
T_1	165.57	56.94	45.50	122.62	19.03	8.97	14.68	14.23
T_2	187.09	46.19	34.00	89.09	23.78	28.66	25.71	26.05
T_3	176.98	76.88	20.12	91.32	20.10	29.22	31.29	26.87
T_4	177.97	88.34	41.09	102.47	27.84	24.75	24.92	25.84
T_5	184.39	64.18	55.65	101.41	28.73	25.30	24.43	26.15
T_6	189.72	101.47	41.93	111.04	24.78	26.83	24.52	25.38
T_7	184.98	63.37	71.09	106.48	27.69	4.96	13.60	15.41
T_8	163.71	128.04	66.05	119.27	28.69	35.21	37.89	33.93
T_9	177.23	107.19	61.48	115.30	29.89	41.65	40.45	37.33
T_{10}	178.15	65.54	45.99	96.56	19.48	19.73	22.20	20.47
T_{11}	171.71	82.58	34.87	96.39	24.55	29.04	30.25	27.95
T_{12}	165.61	90.08	40.91	98.87	22.21	10.80	13.72	15.58
Mean	176.93	80.90	46.56	104.23	24.73	23.76	25.31	24.60
S.Em.±	5.89	6.45	3.25	3.11	2.03	1.29	1.61	0.96
C.D. at 5%	16.95	18.54	9.36	NS	5.85	3.70	4.62	2.71
C.V. %	6.66	15.93	13.98	10.32	16.43	10.83	12.69	13.58
Y * T	S.Em.± 5.38		C.D. at 5% 15.10		S.Em.± 1.67		C.D. at 5% 4.69	

10. Available Phosphorus: The data presented in table 5 revealed that Available P_2O_5 content of LTFE soils at 1st year was significantly differing among various treatments but almost same in all plots of treatments. After 10th, 20th year and when pooled over years, it was also found significantly affected due to treatments. The significantly highest value 41.65, 40.45 and 37.33 Kg ha^{-1} P_2O_5 were recorded under T_9 (25 t FYM to G'nut only) after 10th, 20th years & when pooled over years, respectively. The Y x T interaction was also found significant. Tripathi and Minhas (1991) reported that addition of FYM increased transformation of phosphorus. The results are supported by earlier works of Balaguravaiah *et al.,* (2015) [2] investigated that application of 100% RDP in high P soil (Available P_20_5 67 kg ha^{-1}) in wheat-maize cropping system. Varalakshmi *et al.,* (2005) [18] who reported that Available P significantly improved with the use of 100% recommended fertilizer + 7.5 t FYM ha^{-1}. Overall, there was decreased in status of Available P_2O_5 of in LTFE soils under all treatments, except treatments which were received FYM *i. e.* T_8 & T_9, where status was increased due to release of organic acids from FYM which make conversion of Fixed-P to plant available forms.

11. Depletion percent of different forms of phosphorus

After a span of 20 years most of the phosphorus fraction depicted negative trend in percent depletion in LTFE soils, except Al-P, Fe-P & Ca-P where positive depletion recorded (table 6). Inter-conversion is a distinct possibility under natural soil conditions. Additionally, the type of plant grown on the site also influences the transformation of P in soil. These results were also in agreement with the finding of Setia and Sharma (2007) [15] found that the application of P (17.5 or 135 Kg P ha^1) increased all the forms, irrespective of growth stage whereas, N (120 and 180 Kg ha^{-1}) and K (0 and 33.2 Kg ha^{-1}) application caused decrease in the P fraction. Olsen-P in control plot ($N_0P_0K_0$) decreased from its initial status of 6.50 to 5.75 mg Kg^{-1} after 22 cycle of maize-wheat sequence. Jain and Sarkar (1979) found that Ca-P and Fe-P got converted to Saloid-P and Al-P after wheat harvest. They were of the opinion that it was due to exudation of HCO_3^- and H^+ by wheat roots, which helps in conversion of Ca-P and Fe-P to Saloid-P and Al-P. The removal of phosphorus by crop is only marginal compared to the other two major nutrients and hence continuous addition of phosphatic fertilizers is bound to increase the concentration of total P in the soil and several workers have noticed similar results (Jones and Ruckman, 1973; Ryan and Zahard, 1980) [7, 14]. In case of Al-P and Fe-P maximum depletion percent were noted in T_7 and T_{11}, respectively, while lowest per cent depletion were noted in T_3 (150% NPK) in both the fractions. Whereas in case of Ca-P and Available-P, the highest positive per cent depletion were recorded in T_3 & T_7, respectively, and it was lowest in T_8 & T_6 respectively. In Available P fraction negative per cent depletion also noted in T_2, T_3 T_8, T_9, T_{10} & T_{11}. In case of Total-P, positive per cent depletion was noted only in treatments which did not receive P nutrition through fertilizers (T_7).

Table 6: Percent depletion of different forms of Phosphorus after groundnut-wheat sequence in LTFE soils.

Treat.	Total-P	Inorg.-P	Org.P	Saloid-P	Al-P	Fe-P	Red.-P	Occl.-P	Ca-P	Av.-P
T_1	-106.26	-183.18	7.63	27.95	16.92	94.06	-481.68	29.89	72.51	22.85
T_2	-144.034	-12.38	-333.24	-181.79	51.26	89.67	-243.08	-615.78	81.82	-8.11
T_3	-199.49	-81.31	-427.35	-95.95	-130.09	69.25	-147.16	-174.55	88.63	-55.67
T_4	-170.51	-108.73	-297.20	-10.61	56.67	88.61	-152.77	-230.67	76.91	10.48
T_5	-337.81	-133.45	-887.47	-226.66	64.61	94.3	-258.16	-4.75	69.81	14.96
T_6	-239.26	-139.49	-383.44	-955.26	46.20	75.78	-144.74	-471.49	77.89	1.04
T_7	36.49	2.94	56.40	-96.29	70.30	94.58	-130.77	-290.51	61.56	50.88
T_8	-33.29	-98.01	39.31	-2381.36	-49.57	93.75	-363.75	-62.29	59.65	-32.06
T_9	-182.08	-129.66	-277.05	-2775.53	-19.83	93.38	-501.56	-506.47	65.31	-35.32
T_{10}	-107.57	-24.47	-183.45	-1032.62	53.02	92.48	-159.49	-284.92	74.18	-13.96
T_{11}	-71.26	-74.00	-66.16	-30.16	40.64	95.27	-124.62	-12.24	79.69	-23.21
T_{12}	-114.93	-31.28	-243.88	-1.5	35.61	89.57	-275.95	-57.03	75.29	38.22

Conclusion

It has been concluded from the Long Term Fertilizer Experiment (LTFE) in Junagadh constituting medium black calcareous soil derived from Trap basalt that the soil available forms of the phosphorus ascribed depletion over time irrespective of fertilizer treatments, except in treatments which received FYM along with inorganic fertilizers. An application of FYM not only sustains fertility, but also increases soil fertility status as like here in P_2O_5 status of the LTFE soil in treatments which received FYM, increased Available-P status in LTFE soils from low category to medium category.

The combined application of FYM and inorganic fertilizers in continuous manner, have sustained the crop yield.

The dynamics of phosphorus along with their forms exhibited variable trend, in general some forms exhibited negative trend and some of them ascribed positive trend with varying magnitude according to the soil.

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