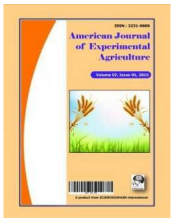

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Effect of Phosphorus Fertilizer and Poultry Manure on P Fractions in Some Derived Savanna Soils of South Western Nigeria-A Greenhouse Study

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Authors' contributions

This work was carried out by author AOO under the supervision of author MTA as the major supervisor and authors KAO and COA as co-supervisors during author's AOO Ph.D programme. All authors read and approved the final manuscript.

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ABSTRACT

The availability of phosphorus (P) in derived savanna soils differs among soil types and the effect of amelioration on the soil P are site specific. The study was conducted to determine the effect of P fertilization and poultry manure on the distribution of P in some derived savanna soils. The greenhouse experiment was carried out in the greenhouse of the Institute of Agricultural Research and Training (I.A.R & T), Ibadan. The treatments consisted of five rates of poultry manure (0, 5, 15 and 20 t ha^{-1}) and five rates of phosphorus (0, 15, 30, 45 and 60 kg P ha^{-1}) applied as single superphosphate (SSP) and this was replicated three times. The soil was cropped with maize and there were two cycles of cropping. Organic P was the largest extractable P fraction while Al-P and Ca-P fractions were the least extractable P fraction. The inorganic P fractions (Fe-P, Al-P, Ca-P, reductant soluble P and residual P) all increased in the soil series. Although there were more of increases in the P fractions in the second greenhouse studies, some treatments reduced the P fractions. Application of 30 kg P ha^{-1} of SSP with different rates of poultry manure was effective in

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increasing the total P and Fe-P fractions in Temidire series while it was the combined application of 45 kg P ha^{-1} of SSP with different rates of poultry manure in Apomu series.

Keywords: P fractions; poultry manure; soil series; SSP.

1. INTRODUCTION

Soils of Nigeria like other parts of sub-Saharan Africa are poor compared to most other parts of the world. Inherent poor fertility in these soils has been attributed to short supply of phosphorus. Low phosphous in some savanna soils have been reported by various authors [1,2]. Various factors could be responsible for P availability to crop plants. These include the form of native soil P, type of P applied to the soil and soil reaction. Phosphorus reaction in the soil makes phosphate, the form by which plants take up P to be either in the solution pool, active pool or in the fixed pool. One unique characteristic of P is its low availability due to slow diffusion and high fixation in soils. However, application of poultry litter to cropland may increase metal mobility, because the soluble organic ligands in poultry litter can form water- soluble complexes with metals [3]. All of this means that P can be a major limiting factor for plant growth. Applications of chemical P fertilizers and animal manure to agricultural land have improved soil P fertility and crop production, but caused environmental damage in the past decades [4]. Soil P exists in various chemical forms including inorganic P (Pi) and organic P (Po). These P forms differ in their behavior and fate in soils [5]. Pi usually accounts for 35% to 70% of total P in soil [6]. Effect of the application of chemical P fertilizers and animal manure on P fractions differs with soils and the fertilizer applied. Manure application for instance has resulted in a significant increase in all the fractions considered i.e Fe-P and Ca-P [7] while added fertilizer P has been observed to increase NaHCO3-P, NaOH-P and the residual P fractions in a separate experiment [8]. Different soils in the southwestern Nigeria has been studied as relating to the effect of fertilization on P fractions [9] but with no coverage of the study area used for this research work. In this study the effect of added P to poultry manure on P fractions in three low-P derived savanna soils was studied.

2. MATERIALS AND METHODS

2.1 Background Study

The soil samples were collected from two farmland located in the derived savanna zone of the southwestern part of Nigeria (Table 1). The farms have been cropped with maize and cassava for four years without fertilizer application. The classification of the soils on the series level followed earlier classification [10].

2.2 Soil Chemical Analysis

Total P was determined by wet digestion using perchloric acid and nitric acid while organic P was by ignition method. Phosphorus concentration in the digests was determined using the ascorbic acid method [11].

2.3 Characterization of the Poultry Manure Used

Total analysis of the sample was done by weighing 0.5 g of poultry manure adding 10 ml of HNO_3 / $HClO_4$, (2:1) and digesting at 150ºC. The temperature was increased at 1.5 hours to 230 ^{0}C and 2 ml of HCl /H_2O (1:1) was added. The digestion was now continued for another 30 minutes [12].

2.4 Phosphorus Fractionation Study

Fractionation procedure [13] was used to quantify different forms of inorganic P in the studied soils. Fractionation was done on the soil before and after amendment for the greenhouse studies.

Table 1. Source of the soils used

Location	State	Site location	Vegetation	Soil series	Soil class (USDA)
Ogbomosho I	Oyo	Lat 8º17.66ᴵN Long 4º10.86ᴵE	Derived Savanna	Temidire	Ferrudulf
Ogbomosho III	Oyo	Lat 8º17.93ᴵN Long 4º10.94ᴵE	Derived Savanna	Apomu	Hapludualf

2.5 Greenhouse Studies

The experiment was carried out in the greenhouse of the Institute of agricultural Research and Training, Ibadan. Five kilogram of air dried, sieved soils from the 2 different locations were used for the experiment. The treatment in the greenhouse consisted of 5 rates of poultry manure (0, 5, 10, 15 and 20 t ha^{-1}) and 5 rates of phosphorus (0, 15, 30, 45 and 60 kg P ha^{-1}) as applied as single superphosphate (SSP). The treatments were arranged in the greenhouse as a 5 X 5 factorial experiment in a completely randomized design (CRD) with 3 replicates. Two weeks after application, three seeds (TZB-SR) were planted per pot and later thinned to two plants per pot. Soil samples were taken before and after harvest and analyzed for P forms. The experiment was then repeated for another 6 weeks.

2.6 Statistical Analysis

The data collected were subjected to analysis of variance using the statistical analysis system (SAS) – general Linear Model [14]. Means were separated by Duncan Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Initial Phosphorus Fractions of the Two Soils

The total P content of the soils was in the order Temidire series > Apomu series. In Temidire series, Al-P had the highest contribution to total P content of the soil, followed by organic P while Ca-P was the least (Table 2). A similar result was obtained in a study on the characterization of phosphorus status in soils of the Guinea Savanna zone of Nigeria [15] where the initial total P in another two derived Savanna soils have been reported to vary. The various P fractions extracted i.e. both the organic and inorganic P fractions were in low amounts in Apomu series. The difference in the two soils could be due to the different parent materials.

3.2 Characterization of the Organic Manure Used

The percentage of N.P.K in the poultry manure was 5.82:5.54:0.94 (Table 3). Invariably some mineralization process has taken place which is evident in the N and P values. The value of organic C (13.38%) was also a confirmation of carbon release from the cured poultry manure used. Although the C: N ratio was low, the residual effect of the poultry manure applied was still evident in the second greenhouse studies carried out. However, some micronutrients were present in the poultry manure.

3.3 Effect of the Combined Application of Poultry manure and SSP on the Various P Fractions in Temidire Series during the First Greenhouse Studies

The sole and combined application of the two treatments had a significant effect on the total P as well as the organic and inorganic P extracted (Table 4a,b,c). After crop removal in the first greenhouse studies, the combined application of 20 t ha^{-1} of poultry manure and 30 kg P ha-^{1} of SSP had the highest total P. Poultry litter application to soils have been observed to significantly increase total P [16]. In this soil type, the order of the P fractions was organic P > Fe-P > occluded P > reductant soluble P > residual P > Al-P≈ Ca-P. As observed for total P, the combined application of the two treatments i.e. the combined application of 10 t ha^{-1} of poultry manure and 30 kg P ha^{-1} of SSP gave the largest organic P fraction. In some studies, soil organic P has been observed to be mainly derived from manures, plant material and the products of the decomposition [17,18]. Fe-P which has been considered as the sink of this soil was higher when poultry manure was applied alone than when SSP was solely applied. This was observed with the sole application of 15 t ha^{-1} of poultry manure which was not too different from when 10 t ha^{-1} of poultry manure was applied. Application of 15 t ha^{-1} of poultry manure and 30 kg P ha^{-1} of SSP however gave the highest amount of Fe-P. Phosphorus occlusion was significantly reduced when poultry manure was applied solely especially with the sole application of 15 t ha^{-1} which was not too different from when 20 t ha^{-1} of poultry manure was applied. Fe-P was significantly increased with the sole application of poultry manure as compared to the sole application of SSP. The highest extractable Fe-P fraction resulted from the combined application of 15 t ha^{-1} of poultry manure and 30 kg P ha^{-1} of SSP. There were reductions in Al-P, Ca-P, reductant soluble P and residual P fractions as compared to the initial P fraction.

Table 2. Initial phosphorus fractions of the different soils

	Total P	Organic P	Al-P	Ca-P mg P kg^{-1}	Fe-P	Occluded P	Reductant soluble P	Residual P
Temidire series	273.08	52.09	68.39	22.10	38.96	27.83	30.32	33.39
Apomu series	207.51	44.52	44.52	27.90	7.79	44.52	25.70	12.56

Table 3. Characterization of the poultry manure used

Nitrogen (N) (%)	**5.82**
Phosphorus (P) (%)	5.54
Potassium (K) (%)	0.94
Na (%)	1.30
SO_4-S (%)	0.14
Organic C (%)	13.38
C/N	2.30
Calcium (%)	8.04
Magnesium (%)	0.61
Iron (mg kg^{-1})	1555
Copper (mg kg^{-1})	33.30
Zinc (mg kg^{-1})	100.30
Manganese (mg kg^{-1})	180.00

3.4 Effect of the Combined Application of Poultry Manure and SSP on the Various P Fractions in Temidire Series during the Second Greenhouse Studies

In the second greenhouse studies, the total P in the soil reduced as compared to the first greenhouse studies when the treatments was applied alone and in combination (Table 5a,b,c). Organic P decreased when SSP was applied alone [19] but increased with the sole application of 5 t ha^{-1} poultry manure and when it was combined with SSP. A similar trend was observed also for the inorganic P fractions. In other words, plant removal without further amelioration of this soil type will result into the reduction of both the organic and inorganic P fractions [20]. However, mineralization of the organic P fraction which increased with some combined application is a major contributor to the release of P into the soil solution during the second cycle of cropping.

3.5 Effect of the Combined Application of Poultry Manure and SSP on the Various P Fractions in Apomu Series during the First Greenhouse Studies

Effect of the sole and combined application of the two treatments on the various P fractions was significant. There was an increase in total P over the initial value when SSP was applied alone and in combination with SSP (Table 6a, b,c). The largest total P fraction was observed with the application of 45 kg P ha^{-1} of SSP. Organic P increased when the treatments where applied solely and when combined.

However, the most significant increase in organic P was observed with the combined application of poultry manure with SSP. Al-P, Ca-P, Fe-P, occluded P and the reductant soluble P fractions reduced when compared to the initial values. Phosphorus adsorption to soil particles can be greatly reduced with the application of organic substances [3]. In the first greenhouse studies it was observed that there was an increase in the residual P fraction as compared to the control.

Table 4a. Effects of the application of poultry manure on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments **PM (t ha^{-1})**	**Total P**	**Organic P**	**Al-P**	**Ca-P**	**Fe-P**	**Occluded P**	**Reduc soluble P**	**Residual P**
0	262.42e	53.12e	56.98a	24.15a	35.76d	30.33a	28.96a	23.12a
5	364.21c	120.62d	8.04b	4.45d	131.92c	18.52c	25.43b	15.23e
10	421.72b	128.89c	5.60cd	5.21b	161.73ab	20.23b	19.37c	20.70c
15	340.87d	279.35a	4.95d	5.04bc	162.79a	17.46d	13.73d	16.45d
20	424.80a	137.50b	5.73c	4.94c	153.22b	17.46d	4.79e	21.15b

Table 4b. Effects of the application of SSP on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc Soluble P	Residual P
0	262.42e	53.12e	56.98a	24.15a	35.76e	30.33e	28.96b	23.12b
5	360.14d	131.88c	4.95c	5.86b	115.44d	73.42b	4.47d	24.12ab
10	385.29c	85.29d	4.27d	4.85cd	150.79a	31.92d	23.51c	6.20d
15	406.46b	177.48b	6.60b	4.89c	143.11b	47.56c	2.45e	24.37a
20	465.83a	184.38a	5.97bc	4.70d	122.89c	86.74a	42.05a	19.10c

Table 4c. Effects of the combined application of poultry manure and SSP on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments PM (t ha^{-1})	P rates (kg P ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
5	15	411.08h	159.73i	5.95b	5.01cd	128.21k	79.71f	17.66h	14.80l
	30	426.82g	183.73d	4.82f	4.12g	165.98b	15.77o	23.30e	29.10a
	45	398.63j	101.88o	5.96b	4.85e	141.74e	105.55b	13.83j	24.82e
	60	402.76i	123.73m	5.73c	5.15bc	131.40j	99.59c	11.72l	25.43d
10	15	433.88f	173.12g	5.18d	4.90de	140.98f	51.29k	36.39b	22.02h
	30	506.40b	318.13a	6.05b	5.06bc	117.57n	29.47n	12.98k	17.15k
	45	373.35k	80.15p	4.90ef	4.75e	132.47i	98.53d	29.79d	22.75g
	60	332.92n	150.80j	6.92a	5.20b	99.59o	11.60p	30.54c	28.28b
15	15	373.69k	175.60f	4.27g	4.74e	94.48p	60.41i	16.39i	17.80j
	30	434.77f	180.17e	4.74f	5.09bc	169.18a	44.46l	6.92m	24.20f
	45	454.56c	166.25h	6.97a	5.02cd	161.73c	71.71h	13.62j	29.27a
	60	441.21e	145.25l	7.03a	4.45f	139.92g	74.27g	41.19a	29.10a
20	15	446.77d	210.20b	4.05h	5.06bc	146.83d	52.46j	20.11g	8.06n
	30	513.48a	206.25c	5.03de	4.83e	137.26h	110.87a	21.92f	27.32c
	45	361.43m	110.63n	6.02b	4.55f	127.15l	82.14e	12.87k	18.08i
	60	365.30l	147.50k	6.86a	5.75a	124.49m	40.47m	30.64c	9.59m

Means with the same letters are not significantly different from each other

Table 5a. Effects of the application of poultry manure on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc Soluble P	Residual P
0	242.23d	48.90e	60.15a	23.22a	30.52cd	24.22a	28.18b	11.04d
5	316.28c	135.00b	8.06b	4.89c	22.56d	15.12c	31.07c	29.58c
10	314.52cd	118.75c	6.60d	5.21b	47.77a	11.93e	15.85d	28.41cd
15	343.21b	180.63a	7.34c	4.89c	37.24b	18.95b	30.64c	33.52b
20	364.64a	108.75d	5.85e	5.11bc	32.56c	13.42d	83.63a	35.32a

Table 5b. Effects of the application of SSP on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc Soluble P	Residual P
0	242.23e	48.90e	60.15a	23.22a	30.52b	24.22e	28.18b	11.04d
5	361.33b	130.63b	6.28bc	5.31c	37.24a	98.95b	30.64a	23.30a
10	267.23d	67.23d	6.92b	5.11d	30.00bc	65.01d	9.58c	18.73b
15	403.32a	80.63c	5.43c	4.78e	29.37c	100.23a	5.96e	16.92c
20	275.40c	140.38a	5.43c	5.64b	27.24d	73.84c	6.38d	16.49cd

Table 5c. Effects of the combined application of poultry manure and SSP on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho I (Temidire Series)

Treatments									
PM (t ha^{-1})	P rates (kg P ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
5	15	374.39c	120.02k	8.19b	10.75a	42.32e	95.87c	70.97a	26.28a
	30	329.99h	158.67f	5.53h	5.12g	51.92a	81.08f	9.27g	18.41d
	45	366.30e	210.20b	4.79l	5.00hi	46.82c	73.42h	9.15h	16.92h
	60	298.20k	144.30h	5.40hi	4.89j	22.56j	91.08e	15.64d	14.33l
10	15	279.33n	122.50j	7.55c	5.43d	43.73d	75.76g	7.87j	16.49i
	30	413.23a	249.35a	8.09bc	5.03h	27.13i	92.46de	9.04i	22.13b
	45	270.21o	107.50l	6.60e	5.11g	22.98j	92.69d	20.11c	15.22j
	60	284.66m	170.02e	5.19j	4.05	15.22l	60.21i	13.09d	16.89h
15	15	346.70g	188.75c	6.28f	6.81b	20.85k	96.82c	9.21gh	17.98f
	30	288.55l	128.75i	5.32i	5.21fg	20.32k	102.14b	8.72ij	18.09e
	45	350.47f	177.50d	9.63a	5.32de	31.07h	100.56bc	5.64l	20.75bc
	60	249.81p	100.04m	4.68m	5.25f	52.56a	59.00j	10.43f	17.85fg
20	15	307.08j	129.38i	6.92d	5.32de	49.05b	90.23ef	6.92k	19.26c
	30	322.51i	150.63g	5.03k	4.79j	33.84g	101.72b	8.94i	17.56g
	45	376.35b	150.02gh	5.03k	5.03h	40.64f	125.55a	34.47b	14.36k
	60	330.65h	158.10fg	5.85g	6.10c	45.02cd	80.93f	12.94e	21.71b

Means with the same letters are not significantly different from each other

Table 6a. Effects of the application of poultry manure on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments								
PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
0	187.13d	42.34d	42.82a	26.16a	7.78a	43.85a	10.12c	14.06d
5	225.40c	81.50c	3.08d	25.96ab	4.89d	13.49c	35.75a	42.98a
10	177.50e	88.13b	4.20b	5.96c	5.03c	17.66b	4.79d	41.73a
15	255.27a	158.75a	3.93c	6.72b	5.43bc	12.03d	0.53e	33.30b
20	244.43b	159.38a	4.08bc	7.34b	5.53b	14.05c	13.62b	30.43c

Table 6b. Effects of the application of SSP on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments								
PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
0	187.13d	42.34d	42.82a	26.16a	7.78a	43.85a	10.12c	14.06d
5	177.50e	99.38a	3.88d	6.17d	5.11bc	19.47d	0.53e	33.30b
10	194.48c	96.88b	3.86d	7.77b	5.21b	42.13ab	3.74d	24.89cd
15	380.41a	96.25b	4.20c	6.81c	4.93c	31.18c	11.28b	25.76c
20	266.36b	59.38c	5.15b	7.66b	7.77a	33.62b	11.60a	41.18a

Table 6c. Effects of the combined application of poultry manure and SSP on phosphorus fractions in the first greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments									
PM (t ha^{-1})	P rates (kg P ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
5	15	224.03f	141.25c	4.05hi	8.30a	4.89fg	31.49l	5.11h	28.94k
	30	165.85m	70.04o	3.70	6.28h	4.89fg	43.81e	5.53g	31.60i
	45	232.26e	122.50f	4.85d	6.59g	4.79g	52.35a	11.60a	29.58j
	60	174.38l	95.04k	4.20g	6.81f	7.87b	31.71k	6.60e	22.15n
10	15	202.34i	123.68e	3.94i	6.70fg	5.11e	30.22n	4.89i	27.79l
	30	221.95g	121.88g	3.90i	6.59g	5.00ef	41.50h	4.89i	38.19f
	45	221.17g	113.75i	6.05b	6.70fg	4.56h	51.39d	5.53g	33.19h
	60	184.53j	80.63m	4.40f	8.10b	7.66c	31.81k	5.97f	45.96a
15	15	248.05b	156.81b	6.00b	7.66d	5.12e	31.28m	3.62j	37.56g
	30	185.17j	80.21n	6.65a	6.81f	4.79g	42.13g	5.64g	38.94e
	45	238.59d	117.50h	4.47ef	7.66d	7.45d	52.03b	5.97f	43.52b
	60	212.79h	110.63j	4.35f	7.48e	7.45d	36.07j	7.34d	39.47d
20	15	213.51h	110.56j	4.17gh	7.87c	5.11e	40.89i	5.21h	39.69d
	30	179.09k	88.43l	5.10c	6.28h	5.01ef	42.45f	5.96f	25.86m
	45	364.97a	242.50a	4.60e	8.30a	7.34d	51.71c	10.94b	39.58d
	60	240.40c	138.03d	4.02hi	8.06b	16.38a	22.60o	10.55c	40.75c

Means with the same letters are not significantly different from each other

3.6 Effect of the Combined Application of Poultry Manure and SSP on the Various P Fractions in Apomu Series during the Second Greenhouse Studies

In the second greenhouse studies, total P increased as compared to the first greenhouse studies (Table 7a, b, c). Sole application of poultry manure accounted for more of total P than when SSP was applied alone. The highest extractable total P fraction was observed with the combined application of 10 t ha^{-1} of poultry manure and 45 kg P ha^{-1} of SSP. Organic P also increased as compared to the first greenhouse studies and this was observed with most treatment combinations. There was more of the organic P fraction when poultry manure was applied alone than with the sole application of SSP. Manure contains large amount of organic P [21] and can be released to increase soil phosphorus concentrations by mineralization. The combined application of 10 t ha^{-1} of SSP and 45 kg P ha^{-1} of SSP gave the largest organic P fraction. There were significant increases in Al-P and Ca-P fractions as compared to the first greenhouse studies. Both the sole application of SSP and poultry manure as well as the combined application were effective in increasing the soil Fe-P in the second greenhouse study. When Fe-P builds up it can act as a sink of P [22] and can serve as a source of P for plants if the resin and Bic-Pi are extremely low. Although occluded P increased, poultry manure reduced the P occlusion when applied solely. There was a slight increase in reductant soluble P fraction while residual P, the recalcitrant P fraction decreased.

Table 7a. Effects of the application of poultry manure on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments								
PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
0	193.65d	42.52e	45.10a	24.15b	11.56d	51.01a	9.94d	9.37c
5	469.32c	188.15b	5.11d	29.10a	106.83b	27.04b	10.64d	12.45a
10	495.40b	168.77d	6.19b	8.05d	101.29c	25.02c	73.42a	12.66a
15	576.06a	252.06a	5.85c	10.15c	125.02a	16.66e	12.13c	10.28b
20	467.29c	175.63c	5.84c	8.22d	101.72c	23.85d	52.35b	9.68c

Table 7b. Effect of the application of SSP on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments PM (t ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc soluble P	Residual P
0	193.65e	42.52e	45.10a	24.15a	11.56d	51.01d	9.94cd	9.37d
5	422.09b	88.75a	5.85c	10.11d	105.76b	108.95cd	40.75a	11.92c
10	466.84a	52.42c	5.85c	12.04b	125.02a	146.83a	9.04d	15.64b
15	419.10c	68.13b	5.43d	9.07e	91.72c	120.17b	9.79c	14.79bc
20	411.93d	45.04d	7.66b	11.13c	106.19b	110.46c	11.23b	20.22a

Table 7c. Effects of the combined application of poultry manure and SSP on phosphorus fractions in the second greenhouse studies using soil samples from Ogbomosho II (Apomu Series)

Treatments PM (t ha^{-1})	P rates (kg P ha^{-1})	Total P	Organic P	Al-P	Ca-P	Fe-P	Occluded P	Reduc Soluble P	Residual P
5	15	501.50f	195.64e	6.38de	12.02f	120.76b	145.77d	8.16l	12.77k
	30	574.54d	180.07f	5.75fgh	8.45l	118.10e	169.18a	84.69a	8.30o
	45	444.79h	149.38h	5.32h	11.90f	110.23i	98.05n	49.37b	20.54d
	60	408.53l	150.05g	6.60cd	10.04j	117.57f	99.27m	7.87m	17.13f
10	15	406.67m	124.38l	5.85efgh	11.50g	103.85l	140.98g	6.70n	13.41j
	30	411.97k	102.50p	5.53gh	12.93e	118.64d	144.17f	17.77i	10.43n
	45	643.73a	376.23a	6.99bc	8.05m	107.89j	110.20j	20.85g	13.51j
	60	620.58b	276.08d	5.53gh	14.20b	105.97k	144.95e	9.69k	22.03c
15	15	463.94g	103.13o	7.24b	10.02j	120.76b	167.05b	44.79c	10.96m
	30	414.42i	135.03k	8.51a	10.38h	113.32h	101.40l	26.49f	19.28e
	45	386.35o	108.73n	5.53gh	13.43c	128.74a	95.95o	19.47h	14.50h
	60	568.09e	290.08c	6.17def	13.00de	100.87m	120.11h	7.66m	30.20a
20	15	463.43g	123.14m	5.64fgh	13.10d	116.51g	158.54c	34.26d	12.24l
	30	390.49n	137.48j	5.96efg	9.23k	99.38n	95.55p	29.05e	13.83i
	45	413.45j	143.75i	5.85efgh	10.20i	116.51g	105.37k	15.32j	16.46g
	60	593.78c	303.13b	5.35gh	14.97a	120.50c	114.97i	9.69k	25.17b

Means with the same letters are not significantly different from each other

4. CONCLUSION

The distribution of the phosphorus fractions after the application of poultry manure and single superphosphate was site specific. Organic P has observed by previous authors was the largest extractable P fraction. However, application of poultry manure in combination with SSP at different rates effectively increased organic P in Temidire series and Apomu series. The inorganic P fractions either increased or decreased in the two soil series depending on the treatment application. The buildup of the inorganic P fractions especially the recalcitrant P fractions was observed in the two series while there were reductions in some soil P fractions. However, the decrease in the inorganic P fractions in two soil series signifies an immediate mineralization in the second greenhouse studies while the decreases observed in the P fractions during the studies is important for maintaining equilibrium between the less available P fractions and the readily available for the sustainability of P in the soil solution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Giwa David D. Ojeniyi SO. Comparative effect of pig manure and N.P.K fertilizer on soil fertility and performance of tomato (*Lycopersicum lycopersicon mill)*. Thesis and dissertations. Crop, soil and pest management. Federal University of Technology, Akure; 2004.

2. Nwoke OC, Vanlauwe B, Diels J, Sanginga N, Osonubi O. The distribution of phosphorus fractions and desorption characteristics of some soils in the moist savanna zone of West Africa. Nutrient Cycling in Agroecosystems. 2004;69(2): 127-141.
3. Faridullah A, Waseem A, Alam A, Irshad M, Sabir M, Umar M. Leaching and mobility of heavy metals after burned and unburned poultry litter application to sandy and Masa soils. Bulgaria Journal of Agricultural Science. 2012;18:733–741.
4. Jianbo S, Lixing Y, Junling Z, Haigang L, Zhaoha B, Xinping C, Weifeng Z, Fusuo Z. Phosphorus dynamics: From soil to plant. Plant Physiology. 2011;56:997-1005.
5. Hansen JE, Cade-Menum, BJ, Strawn DG. Phosphorus speciation in manure amended alkaline soils. Journal of Environmental Quality. 2004;33: 1521-1527.
6. Harrison AF. Soil Organic Phosphorus-A review of world literature. CAB International, Wallingford, Oxon, UK, p 257;1987.
7. Sharpley AN, Smith, SJ. Nitrogen and phosphorus forms in soil receiving manure. Soil Science. 1995;159(4):253--258.
8. Zhang TQ, Mackezie, AF. Change of soil phosphorus fractions under long-term corn monoculture. Soil Science Society of America Journal. 1997;61:485-493.
9. Kolawole GO, Tijani – Eniola H, Tian G. Phosphorus fractions in fallows of West Africa: Effect of residue management. Plant and Soil. 2004;263:113-120.
10. Smyth AJ, Montgomery RF. Soil and land use in Central Western Nigeria. Govt. Printer, Ibadan, Nigeria. 1962;265.
11. Murphy J, Riley JP. A modified single solution method for the determination of phosphate in natural waters. Anal Chim Acta. 1962;27:31–36.
12. Udo EJ, Ogunwale, JA. Manual of soil, plant and water analysis. Department of Agronomy, University of Ibadan, Nigeria; 1978.
13. Chang SC, Jackson ML. Fraction of soil phosphates. Soil Science. 1957;83: 133-144.
14. SAS Institute. SAS for linear models. A guide to the ANOVA and GLM procedures. SAS Inst., Cary, N.C; 2000.
15. Amhakhian SO, Osemwota IO. Characterization of phosphorus status in soils of the Guinea Savanna zone of Nigeria. Nigerian Journal of Soil Science. 2012;22(1):37-43.
16. Ullah F, Amir W, Muhammed I, Qaisar M, Muhammed A, Arif A. Leachability of phosphorus in soils after application of burned and unburned poultry litter. 2012; 7(5):834-840.
17. Sylvia DM, Hartel PG, Fuhrmann JJ, Zuberer DA. Principles and applications of soil microbiology. Pearson Education Inc., NJ; 2005.
18. Morgan MA. The behavior of soil and fertilizer phosphorus. In phosphorus loss from soil to water. Cab International NY: USA. 1997;137-150.
19. Zhang TQ, Mackenzie AF, Liang BC, Drury CF. Soil test phosphorus and phosphorus fractions with long-term phosphorus addition and depletion. Soil Science Society of American Journal. 2004;68: 519--529.
20. He Z, Griffin, JA, Honeycutt CW. Evaluation of soil phosphorus transformations by sequential fractionation and phosphatase hydrolysis. Soil Science. 2004;169:515-527.
21. Turner BL, Leytern, AB. Phosphorus compounds in sequential extracts of animal manures: A chemical speciation and a novel fractionation procedure. Environmental Science and Technology. 2004;38:6101-6108.
22. Kuo S, Huang B, Bembene. Effects of long-term phosphorus fertilization and winter cover cropping on soil phosphorus transformations in less weathered soil. Biology and Fertility of Soils. 2005;41:116--123.

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