EFFECTS OF DIFFERENT FERTILIZER TREATMENTS ON NUTRIENT (PHOSPHORUS) RELEASE PATTERN IN AN ULTISOLS OF ANYIGBA KOGI STATE, NIGERIA

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Abstract

Incubation study was carried out to assess the effect of pacesetter A and B organic fertilizer, sunshine organic fertilizer, cowdung and single super phosphate fertilizer treatment on soil nutrient (P) release pattern. The study was conducted in soil and Environmental Management Laboratory, Kogi State University, Anyigba. Two levels of pacesetter A and B at 100kg/ha, sunshine at 100kg/ha, cowdung at 100kg/ha, SSP at 100k /ha and combination of PSA + SSP at 50kg/ha, PSB + SSP at 50kg/ha, sunshine + SSP at 50kg/ha, Cowdung + SSP at 50kg/ha and a control were used. These fertilizers were separately mixed with soil constituents. The design was CRD of 10 treatments replicated three times giving a total of 30 experimental units The treatments were replicated thirty (30) times on completely randomized design and sampled were taken at 2, 4, 6, 8, 10 weeks intervals after incubation respectively for analysis. Thirty sub-soil samples were dried, analysed and discarded each weeks. The results indicated that Pacesetter A and B (fortified), sunshine releases more phosphorus content following application of equal rate of organic fertilizer at 100kg/ha, while Cowdung, SSP recorded low release. The use of sole organic fertilizer was effective compared to inorganic in terms of responses of some parameters. The sole organic (P) proportion of 100kg/ha gave the best responses to nutrient released in almost all the parameters in the experiment.

Key words: *ultisol, pacesetter, sunshine organic fertilizer, single super phosphate*

1. INTRODUCTION

There are varieties of media that may require sampling or assessment for agronomic and environmental purposes. These include soil nutrients and by-products that may be applied to soils or that are present in the environment. (Silberbush and Barber, 1983). For agricultural perspective, the specific components of a successful soil testing programme that apply to land-use programme where plant growth and yields are of greatest interest. Often, analysis is designed to determine the concentration of soil and plant nutrients in a media sample, other analysis determines basic chemical (example P^H or electrical conductivity), physical (example Soil bulk density) or biological (example soil respiration, biological oxygen demand) properties that can be indicators of the suitability of soil for plant growth, (Claassen and Barber, 1976). However, from an environmental different soil, there is need to evaluate some specific considerations that relate to soil nutrient release (Peterson and Barber, 1981).

Nutrient analysis has become a useful technique for interpreting nutrient levels in the soil. Use of soil amendments for agriculture and land reclamation operation has also gained its popularity because of the beneficial properties these can provide, including nutrients, organic matter, P^H buffering, as well as other chemical, physical, and biological contributions. (Dahnke and Malcolm 1964). Similarly, total nutrient concentrations in soils are poor predicators of probability of a crop yield response to fertilizer additions. Therefore, attempts are made to either measure a sub-fraction of the total amount of an element in a sample, example extractable phosphorus (P) rather than total P in soil, or to measure the concentration of a particular molecule species of an element, example (No_2) in soil rather than total nitrogen (N). This is important and often confusing concept and it must be certain, what has been measured in a particular analysis.

Efficient nutrient management programmes supply plant nutrients inadequate quantities to sustain optimum crop productivity and profitability while minimizing environmental impacts of nutrients use.

There is paucity of information on the use of these fertilizers in this part of Nigeria. It therefore becomes imperative to carry out such study in order to bridge this knowledge gap.

This study was designed to assess the effect of different fertilizer treatments on nutrient (P) release pattern in soils of Anyigba.

MATERIALS AND METHODS

Experimental location and soil preparation

The research was conducted at Soil and Environmental Management Laboratory, Kogi State University, Anyigba. Soil samples were collected from the top soil (0–15cm) of the University Students' Research Farm. This was used for laboratory physico-chemical analysis and for incubation experiments. The site has been under continuous cropping for over ten years. A composite soil sample was collected from the bulked soil sample, the soil samples were air-dried, crushed and passed through 2mm sieve. Prior to commencement of the incubation studies, the prepared soil samples were analysed for the following parameters: The pH of the soil was determined in 1:2 soil to water suspension using a glass electrode pH meter (McLean, 1982). Organic carbon was determined by Bray and Kurtz (1945) wet dichromate oxidation method. Total Nitrogen was determined by the kjeldahl method. Available phosphorus was extracted by 0.03m NH_4F + 0.25MHCl (Nelson & Sommer, 1982) and the P in the extract was determined by spectrophotometer. Exchangeable bases (Na, Ca, K and Mg) were extracted using 1N ammonium acetate at pH 7.0 (Thomas, 1982). Potassium, calcium and Na were read using flame photometer while magnesium was determined using Atomic Absorption Spectrophotometer (AAS).

Cow-dung Collection and Preparation. Cow-dung was collected from Kogi State University Teaching and Research Animal Farm. It was dried, crushed, sieved and analysed to determine the initial nutrient status. Nutrient elements such as N, P, K, Ca, Mg, Na and organic carbon contents were analysed.

Experimental treatments and design for the laboratory study

The experimental treatments include control (untreated soil); cowdung alone, PS A and B, SS and SSP (each at 100kg/ha), SSP + cowdung, SSP + PSA, SSP + PSB and SSP + SS at 50kg/ha to make a total of 10 experimental treatments as shown in the table below:

Table 1: Treatment and Combination

S/NO	Treatment Code	Treatment Name
1	OO	Control
2	CD	Sole PSA (100kg/ha)
3	PSA	Sole PSA (100kg/ha)
4	PSB	Sole PSB (100kg/ha)
5	SS	Sole SS (100kg/ha)
6	SSP	Sole SSP (100kg/ha)
7	SSP+CD	SSP+ CD (50kg/ha)
8	SSP+PSA	SSP+PSA (50kg/ha)
9	SSP+PSB	SSP+PSB (50kg/ha)
10	SSP+SS	SSP+SS (50kg/ha)

CD = Cow-dung PSA= Pacesetter A PSB = Pacesetter B

(fortified)

SS = Sunshine

Incubation studies

An incubation study (Laboratory experiment) was conducted to determine available P, nitrogen, calcium, sodium, potassium, magnesium, organic matter, pH and exchangeable bases (release patterns). Each of the 10 experimental treatments on table 1 was replicated three times giving a total of 30 experimental units. This was represented in a bucket filled with 10kg soils. They were mixed with appropriate measures of cow dung, pacesetter A and B (fortified) sunshine and single superphosphate according to the experimental treatments in a completely randomized design (CRD). The pot of each experimental unit was watered to 60% field capacity for a period of 10 weeks.

Soil samples were collected from each experimental unit every two weeks for 10 weeks and were analyzed to determine the released nutrients pattern. The results were subjected to statistical analysis and where it was necessary, simple linear correlation and regression were adopted.

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of the Soil and Fertilizer Used

The physico-chemical properties of soil and fertilizer use prior to incubation and treatment are presented in Table 2a & 2b. The soil class was sandy loam and slightly acidic with pH of 6.3. The pH of most agricultural soils in tropics has been reported to range from 5.0 to 6.8 (Udo and Ogunwale, 1977). Organic matter content was 6.31g/kg compared with critical level for optimum crop production given as 30g/kg (Agboola and Corey, 1972). The organic matter was below the range for tropical soils used for crop production. The available P was 6.78, indicating that it was low compared with the critical level which range from 10 – 15mg/kg (Adeoye and Agboola, 1985). This shows that the soil needs amendment for crop optimum production. The total nitrogen was 2.35g/kg indicating that it was higher than the critical level which ranges from 0.01 to 1.20g/kg, (Bremner and Mulvancy, 1982) for tropical agricultural soils. Calcium content was 1.63 Cmol/kg, compared with the critical level; given as 2.6Cmol/kg (Agboola and Corey, 1972). The soil is deficient in Ca, therefore needs amendment for crop optimum production. Exchangeable sodium was 4.61Cmol/kg compared with the critical level of Na which ranges from 0.48 to 0.94 Cmol/kg which means it was higher than the critical level for the tropical soils. Exchangeable magnesium was 5.52 Cmol/kg. The level of magnesium was higher compared to critical level for tropical soils (0.15 Cmol/kg). Exchangeable potassium was 6.37Cmol/kg. This level of potassium needs no amendment for optimum crop production. (Adeoye and Agboola, 1985; Agboola and Corey, 1972).

Table 2a: Physical and chemical properties of soil before incubation

H	N	P(Mg/kg	O/M	Cmol/kg				CEC	Sand	Silt	Clay
			(g/kg)	Ca	K	Na	Mg				
6.3	2.35	6.78	6.31	1.63	6.37	4.61	5.52	30.14	74.24	6.00	19.76

Table 2b: Chemical properties of fertilizer material before incubation

	%N	P (Mg/kg)	K	Na	Ca	Mg
			Cmol/kg	Cmol/kg	Cmol/kg	Cmol/kg
PSA	0.16	1.16	2.76	0.46	2.46	**23.60**
PSB	0.17	1.14	2.44	0.74	13.00	**5.25**
SS	0.15	1.81	4.34	16.1	2.56	**1.55**
CD	0.14	1.50	2.30	0.51	2.90	**0.70**
SSP		**18% P_2O_5**				

Chemical Properties of Fertilizer Material Prior To Incubation

The chemical properties of fertilizer used as treatment prior to incubation are shown in Table 3b. The analysis showed that Na in PSA 0.46cmol/kg, PSB 0.74 cmol/kg, CD 0.551 cmol/kg, SS 16.1 cmol/kg. K in PSA (2.76 cmol/kg), PSB (2.44 cmol/kg), SS (4.34 cmol/kg), CD (2.30 cmol/kg). Ca in PSA 2.46 cmol/kg, PSB 13.00 cmol/kg, SS 2.56 cmol/kg, CD 2.90 cmol/kg. Mg in PSA 2.30 cmol/kg, PSB 5.25 cmol/kg, SS 1.55 cmol/kg, CD 0.70 cmol/kg. N in PSA 0.16%, PSB 0.17%, SS 0.15%, CD 0.14%. P in PSA 1.16 Mg/Kg, PSB 1.14 Mg/Kg, SS 1.18Mg/Kg, CD 1.50Mg/Kg.

Table 3: Soil pH at the various incubation intervals

S/N	Sample ID	2 WK pH	4 WK pH	6 WK pH	8 WK pH	10 WK pH
1	Control	5.7	5.4	5.5	5.0	**5.6**
2	CD	5.5	5.9	5.0	5.8	**6.1**
3	PSA	6.0	5.7	5.8	6.1	**6.0**
4	PSB	6.1	5.9	6.0	5.9	**6.0**
5	SS	5.7	5.9	6.0	6.0	**6.1**
6	SSP	5.5	5.4	5.5	5.4	**5.5**
7	SSP + CD	5.3	5.5	5.9	6.1	**6.0**
8	SSP + PSA	5.4	5.6	5.7	5.8	**5.9**
9	SSP + PSB	6.0	5.7	5.6	6.0	**5.9**
10	**SSP + SS**	**5.8**	**5.9**	**6.0**	**6.1**	**6.3**

Table 4: Nutrients released after 2nd week of incubation

S/N	Treatments	%N	% O/M	Na Cmol/Kg	Ca Cmo/kg	K Cmol/kg	Mg Cmo/kg	Ex-Bases	P mg/kg
1	**Control**	**0.15**	**2.0**	**0.1**	**4.0**	**0.3**	**10.0**	**7.55**	**1.33**
2	**CD**	**0.16**	**2.1**	**0.4**	**3.90**	**0.5**	**3.0**	**10.05**	**2.20**
3	**PSA**	**0.17**	**2.3**	**0.5**	**4.13**	**0.6**	**5.0**	**12.87**	**16.95**
4	**PSB**	**0.18**	**2.3**	**0.7**	**3.51**	**0.7**	**6.0**	**13.39**	**14.32**
5	**SS**	**0.16**	**3.0**	**0.6**	**4.11**	**0.5**	**3.0**	**11.37**	**10.42**
6	**SSP**	**0.14**	**2.0**	**0.3**	**3.46**	**0.6**	**1.0**	**7.5**	**1.29**
7	**SSP+ CD**	**0.16**	**2.2**	**0.5**	**4.35**	**0.4**	**2.0**	**9.61**	**2.26**
8	**SSP+ PSA**	**0.15**	**2.3**	**0.6**	**5.0**	**0.5**	**3.0**	**11.55**	**10.07**
9	**SSP+ PSB**	**0.15**	**2.3**	**0.7**	**5.1**	**0.6**	**4.0**	**12.85**	**5.20**
10	**SSP+ SS**	**0.14**	**2.4**	**0.5**	**6.0**	**0.4**	**2.0**	**11.31**	**4.85**

Table 5: Nutrients released after 4th week of incubation

S/N	Treatments	%N	% O/M	Na Cmol/Kg	Ca Cmo/kg	K Cmol/kg	Mg Cmo/kg	Ex-Bases	P mg/kg
1	**Control**	**0.16**	**2.0**	**0.4**	**3.0**	**0.3**	**1.0**	**6.86**	**1.32**
2	**CD**	**0.21**	**2.2**	**0.5**	**4.80**	**0.5**	**2.1**	**10.31**	**5.56**
3	**PSA**	**0.21**	**3.2**	**0.5**	**5.5**	**0.6**	**22**	**12.34**	**17.23**
4	**PSB**	**0.23**	**3.1**	**0.7**	**5.5**	**1.2**	**2.3**	**13.03**	**14.67**
5	**SS**	**0.20**	**3.0**	**0.5**	**6.0**	**0.6**	**2.1**	**12.4**	**12.10**
6	**SSP**	**0.15**	**2.0**	**0.4**	**5.7**	**0.4**	**10.0**	**9.65**	**3.519**
7	**SSP+ CD**	**0.20**	**2.1**	**0.5**	**4.5**	**0.6**	**2.1**	**9.9**	**4.07**
8	**SSP+ PSA**	**0.20**	**2.2**	**0.6**	**4.9**	**0.5**	**2.2**	**10.0**	**13.01**
9	**SSP+ PSB**	**0.21**	**2.2**	**0.6**	**6.1**	**0.6**	**2.2**	**11.91**	**9.02**
10	**SSP+ SS**	**0.20**	**2.1**	**0.4**	**5.9**	**0.5**	**21**	**11.2**	**7.22**

Table 6: Nutrients released after 6th week of incubation

S/N	Treatments	% N	% O/M	Na Cmol/kg	Ca Cmol/kg	K Cmol/kg	Ex-Bases	P g/kg
1	Control	0.15	2.1	0.2	0.5	2.0	4.95	**0.70**
2	CD	0.17	3.0	0.4	0.6	2.2	6.37	**3.31**
3	PSA	0.18	3.0	0.6	0.6	3.0	7.38	**13.01**
4	PSB	0.18	3.1	0.7	0.8	3.1	7.88	**10.61**
5	SS	0.17	3.1	0.5	0.6	3.0	7.37	**8.50**
6	SSP	0.15	2.0	0.4	0.5	1.0	4.04	**2.91**
7	SSP + CD	0.16	2.2	0.5	0.5	2.0	5.36	**2.40**
8	SSP + PSA	0.17	2.3	0.5	0.5	2.1	5.57	**6.48**
9	SSP + PSB	0.17	2.3	0.6	0.6	2.3	5.97	**6.05**
10	**SSP + SS**	**0.16**	**2.4**	**0.4**	**0.5**	**2.3**	**5.76**	**4.13**

Table 7: Nutrients released after 8th week of incubation

S/N	Treatments	%N	% O/M	Na Cmol/Kg	Ca Cmo/kg	K Cmol/kg	Mg Cmo/kg	Ex-Bases	P mg/kg
1	**Control**	**0.16**	**2.2**	**0.1**	**2.0**	**0.2**	**1.0**	**5.66**	**0.13**
2	**CD**	**0.18**	**2.6**	**0.4**	**4.5**	**0.4**	**3.0**	**11.08**	**8.21**
3	**PSA**	**0.19**	**3.0**	**0.6**	**5.0**	**0.6**	**2.3**	**11.69**	**14.31**
4	**PSB**	**0.20**	**3.0**	**0.7**	**7.0**	**0.7**	**3.0**	**14.6**	**10.64**
5	**SS**	**0.18**	**2.3**	**0.5**	**5.0**	**0.5**	**3.1**	**11.58**	**9.47**
6	**SSP**	**0.15**	**2.0**	**0.4**	**5.0**	**0.3**	**1.0**	**8.85**	**2.49**
7	**SSP+ CD**	**0.17**	**2.2**	**0.5**	**4.5**	**0.6**	**2.1**	**9.9**	**4.07**
8	**SSP+ PSA**	**0.18**	**2.3**	**0.6**	**5.0**	**0.5**	**2.2**	**10.78**	**8.28**
9	**SSP+ PSB**	**0.19**	**2.4**	**0.6**	**6.0**	**0.6**	**2.3**	**12.09**	**6.05**
10	**SSP+ SS**	**0.17**	**2.5**	**0.4**	**7.0**	**0.4**	**2.4**	**12.27**	**5.41**

Table 8: Nutrients released after 10th week of incubation

S/N	Treatments	%N	% O/M	Na Cmol/Kg	Ca Cmo/kg	K Cmol/kg	Mg Cmo/kg	Ex-Bases	P mg/kg
1	**Control**	**0.17**	**2.2**	**0.4**	**3.0**	**0.4**	**0.3**	**6.47**	**3.16**
2	**CD**	**0.18**	**2.5**	**0.5**	**4.0**	**0.6**	**1.0**	**8.78**	**5.86**
3	**PSA**	**0.19**	**2.4**	**0.5**	**6.0**	**0.5**	**3.0**	**12.59**	**15.21**
4	**PSB**	**0.20**	**2.5**	**0.7**	**7.0**	**0.7**	**3.1**	**14.2**	**13.63**
5	**SS**	**0.18**	**2.3**	**0.5**	**6.0**	**0.6**	**4.0**	**13.58**	**12.45**
6	**SSP**	**0.15**	**2.0**	**0.4**	**5.0**	**0.4**	**1.0**	**8.95**	**3.84**
7	**SSP+ CD**	**0.16**	**2.2**	**0.4**	**4.0**	**0.5**	**2.0**	**9.26**	**3.46**
8	**SSP+ PSA**	**0.17**	**2.3**	**0.5**	**5.0**	**0.4**	**2.1**	**10.47**	**11.60**
9	**SSP+ PSB**	**0.18**	**2.6**	**0.6**	**5.0**	**0.5**	**3.0**	**11.88**	**10.44**
10	**SSP+ SS**	**0.17**	**2.4**	**0.4**	**4.0**	**0.5**	**3.2**	**10.67**	**9.05**

Fig 1 Indicate the changes in available P at the various incubation periods for each of the ten fertilizer nutrient sources. It was obvious that control, cow-dung, SSP, and SSP + CD treatments had the lowest values compared to those of PSA, PSB, SS, SSP + PSA, SSP + PSB and SSP + SS. The increase in the P value in some of the fertilizer was as a result of the availability of P which is mostly derived from soil organic matter. Fig 2 shows that changes in pH were not pronounced among the fertilizer nutrients sources. Nevertheless, some significant difference existed among the five incubation period for each of the 10 fertilizer treatments. Fig 3 shows the main effects of fertilizer treatment on both soil pH and available P irrespective of the length of incubation. No notable differences in soil pH, may be due to the short period of incubation involved, significant differences were however obvious in the available P values. Control has the least which is not significantly different from those of SSP and SSP + CD while PSA and PSB had the highest.

Fig 4 shows the main effect of the varying incubation periods of soils, pH and available P. Note that the regression curves and equations are of the quadrate mode. With the high coefficients of determination, it is possible to predict soil p^H and available P values at the various incubation periods covered in the study. Exchangeable Ca did not relate well with other parameters until after 6 weeks of incubation. This shows that the longer the incubation period, the higher the Ca interaction with other parameters. The rate of mineralization of organic matter and that of soil organic P are similar (Balesdent and Wagner, 1988) and this underscores the rate of organic matter in the soil fertility issues, note that organic P under tropical environments may supply a substantial proportion of available P to plants during the process of mineralization.

Under acid condition, exchangeable ion and aluminium come into soil solution presenting some toxicity problems and causing the deficiency of nutrients especially phosphorus.

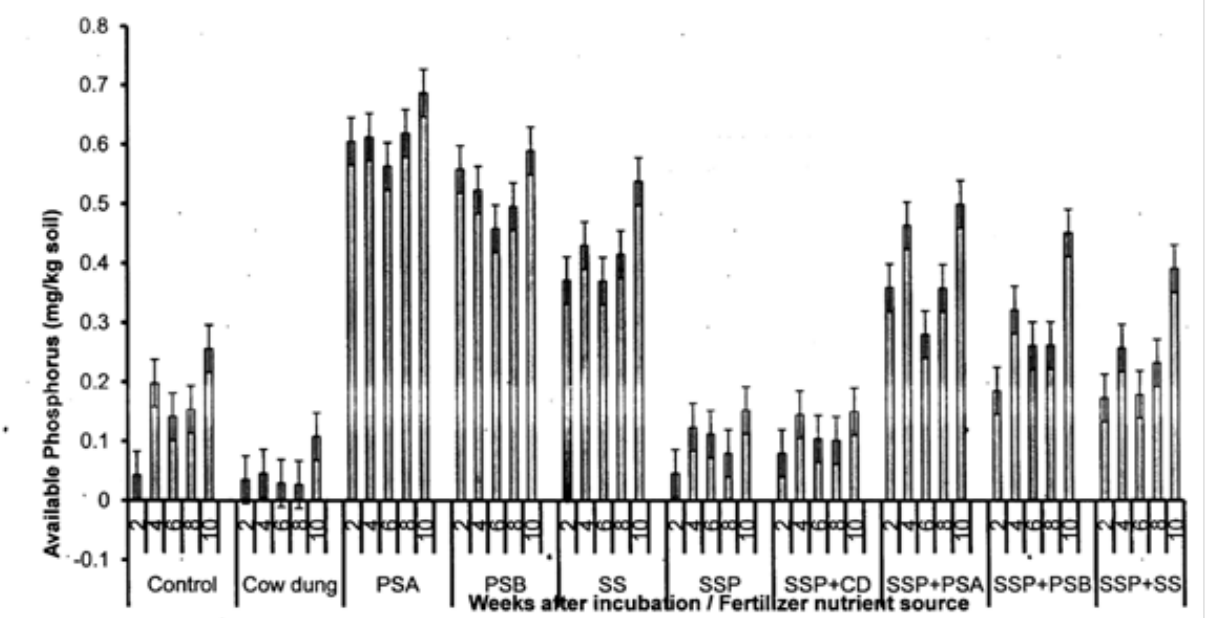
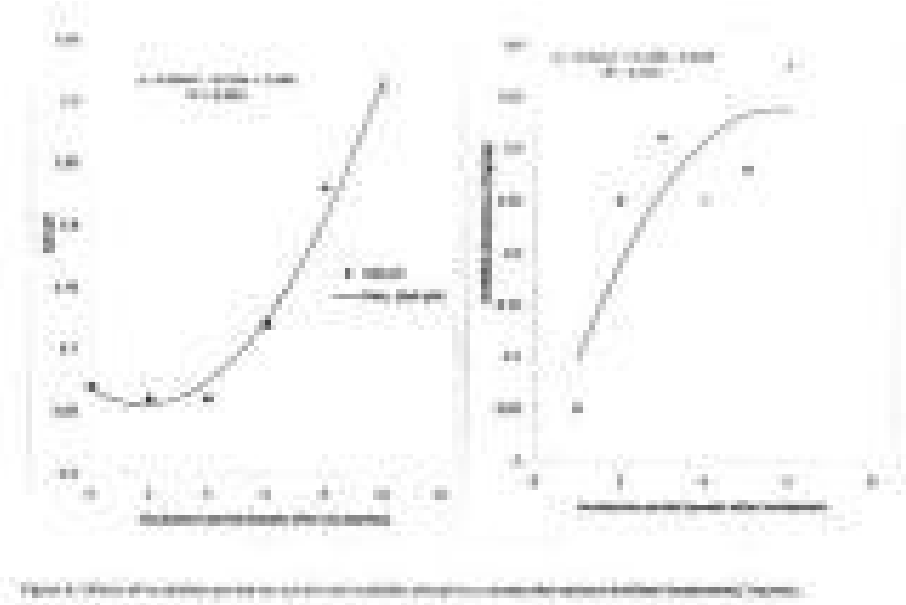


Figure 1: Changes in available phosphorus contents of soil samples incubated (with various fertilizer materials) for different periods *[indicative of the effects of the interaction between fertilizer nutrient source and incubation period on soil available phosphorus] PSA, PSB, SS and SSP = Pacesetter organic fertilizer A, Pacesetter organic fertilizer B, and Single super phosphate, respectively. CONTROL is no-fertilizer treatment.*



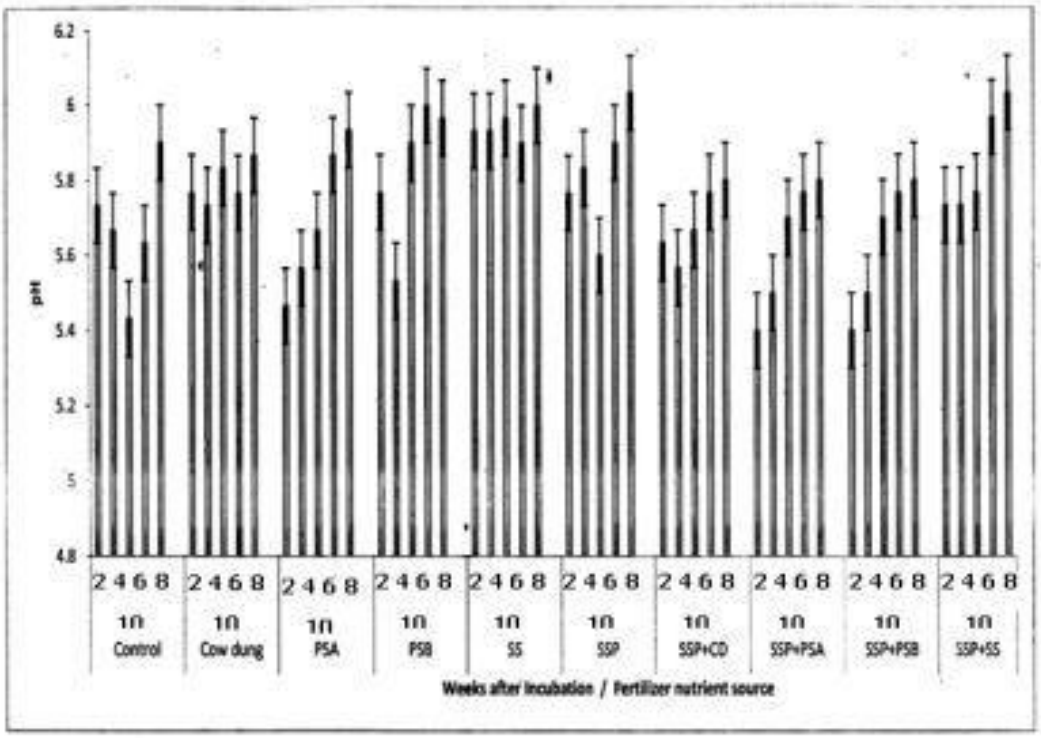


Figure 2: Changes in pH of soil samples incubated (with various fertilizer materials) for different periods *(indicative of the effects of the interaction between fertilizer nutrient source and incubation period on soil reaction) PSA, PSB, SS and SSP = Pacesetter organic fertilizer A, Pacesetter organic fertilizer B, and Single super phosphate, respectively. CONTROL is no-fertilizer treatment.*

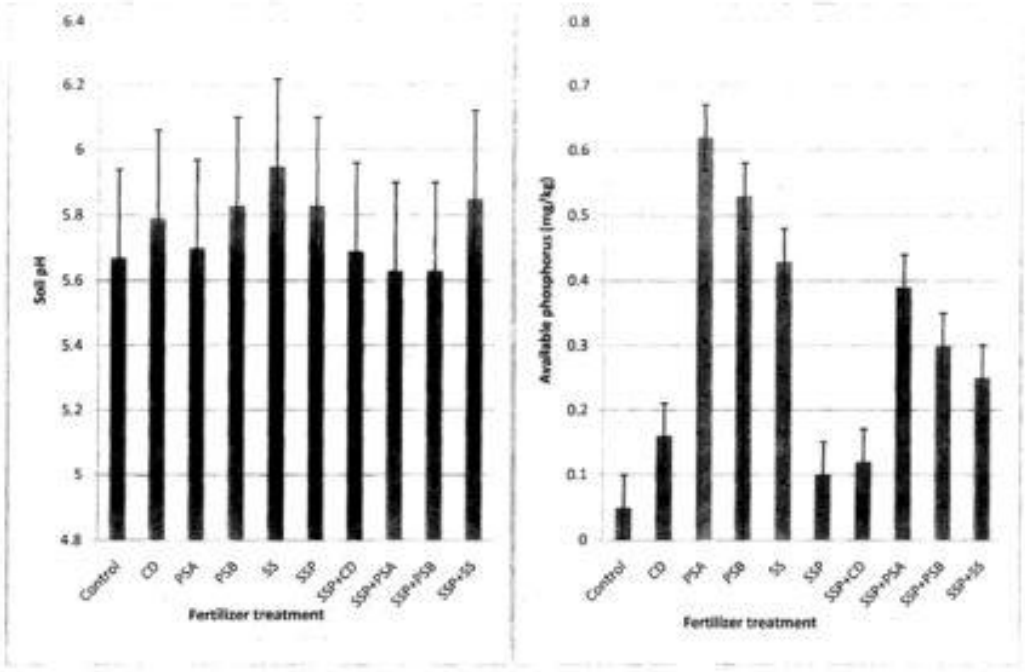


Figure 3: Effects of fertilizer sources on soil pH and available phosphorus across the various incubation periods.
(CD, PSA, PSB, SS and SSP are cow dung, pacesetter organic fertilizer A, pacesetter organic fertilizer B, Sunshine and single superphosphate, respectively)

CONCLUSION AND RECOMMENDATIONS

Pacesetter fertilizer and sunshine fertilizer constituted more than 50% of the P release into the soil. Organic P constitutes the largest percentage of total P released into the soil, hence application of pacesetter fertilizer and sunshine fertilizer enhance more of P released into the soil. There is need for more studies on this experiment before valid conclusion could be made.

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