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SUITABILITY OF MEHLICH - 3 AS A MULTIPURPOSE EXTRACTANT OF PHOSPHORUS AND POTASSIUM IN SOME NIGERIAN SOILS

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ABSTRACT

In Nigeria, procedures for extraction of available phosphorus and exchangeable potassium from the soil involves different extractants. Available Phosphorus is by either Bray 1, Bray 2 or Olsen extractants, depending on agroecological zone from which the soil is taken while exchangeable potassium is by 1M ammonium acetate. Bell pepper, rich in antioxidants, requires phosphorus and potassium for high quality fruit yield. Mehlich-3 (M3), a multi-purpose extractant could extract phosphorus and potassium simultaneously. However, M3 has not been evaluated and adapted for some Nigerian soils. Therefore, M3 as a multi-purpose extractant of P and K from soil for bell pepper was evaluated. Phosphorus and potassium extractions were carried out on soil (0–15 cm) samples from 12 purposively selected sites belonging to eight soil series across three agro-ecological zones (derived savanna, humid forest and northern guinea savanna) of Nigeria. Bray 1 (B1), Bray 2 (B2) and Olsen were used to extract phosphorus; 1M Ammonium acetate pH 7.0 (AAc) was used to extract potassium, while M3, Ammonium hydrogen flouride+DTPA (ABD) and modified M3 (MM3) were used to extract phosphorus and potassium simultaneously. Concentrations of phosphorus and potassium extracted by different extractants were determined using standard procedures. In the screenhouse, pots were filled with 3 kg soil and laid in a completely randomised design (n=108). Bell pepper was grown at one plant per pot for four weeks. Phosphorus and potassium uptakes were determined. Data were analysed using descriptive statistics and correlation at $\alpha_{0.05}$. Phosphorus extracted by B1, B2, Olsen, ABD, MM3 and M3 were 8.34±1.22, 11.19±2.62, 5.11±1.68, 30.33±4.32, 15.68±3.48 and 14.41±4.32 mg/kg, respectively, while potassium extracted by AAc, ABD, MM3 and M3 were 0.47±0.02, 0.21±0.02, 0.36±0.05 and 0.59±0.09 cmol/kg, respectively. Phosphorus and potassium uptakes were 2.34±0.5 and 22.62±2.28 g/kg, respectively. Significant correlations exist between extracted phosphorus and potassium with their uptakes, except ABD for potassium. Correlations of phosphorus and potassium extracted by M3 with their uptakes were the highest (r=0.95), while the lowest was in B1 (0.78) for phosphorus and MM3 (0.93) for potassium. Mehlich-3 is a good simultaneous extractant of phosphorus and potassium across the agro-ecological zones. It is therefore recommended for evaluating soil phosphorus and potassium.

***Keywords:** Multipurpose soil extractants; Mehlich-3 extractant; Phosphorus uptake; Bell pepper yield*

Introduction

Among methods of assessing soil fertility, soil analysis is rated as the best, due to its advantages of being rapid, accurate and timely. Soil testing is defined as the assessment of chemical properties of a soil for predicting accurately its fertiliser requirement (Sobulo and Adepetu, 1987). Through soil testing, a relative measure of the amount of nutrients in the soil is obtained (Matula, 2009).

Efficiency of soil testing programme could be improved by eliminating the need for multiple or separate extractants for P and K. The main concern of this work is the evaluation (correlation) of Mehlich-3 extractant for Phosphorus and Potassium using bell pepper as test crop. Correlating P and K uptake by bell pepper with amount extracted by Mehlich-3 would confirm the suitability or otherwise of Mehlich-3 extractant for P and K (Self, 2004). Matula (2009) considers an extractant to be suitable if it satisfies the following conditions: simultaneous extraction of all important nutrients from the soil, efficient in all soil types, accurate and reproducible, simple, not expensive, good for expeditious detection and relate soil available nutrients to plant nutrients.

Current soil test measurements of available P and exchangeable K for fertiliser recommendation on Nigerian soils involve the use of separate soil extractants (Nzewi, 1979), due to variations in the chemical properties. The National Soil Correlation Committee constituted in 1974, recommended Bray P1 for slightly acidic to neutral soils of Western Nigeria, Bray P2 for acidic Eastern soils and Olsen for the alkaline soils of Northern Nigeria. 1M ammonium acetate pH 7.0 is accepted as universal extractant for K on all Nigerian soils. Existing fertiliser recommendations are based on these extractants. The high cost of soil analysis in Nigeria is a major factor why small scale farmers do not carry out soil testing before planting and this eventually results in low economic returns. In situations where fertiliser application is inevitable, blanket application is adopted. Such a generic fertiliser use in crop production does not only result in low yield and crop quality due to nutrient imbalance but also soil degradation and pollution.

Development of a field calibration data base for a new soil testing extractant is an essential, but expensive and time-consuming process (Sims, 1989). Deriving conversion equations between M3 and current extractants would allow for the use of the new extractant with existing field calibration data.

Bray 1and 2 soil extractants are single element extractants as developed for Phosphorus extraction by Bray and Kurtz (1945) although Ayodele and Agboola (1981) and Adeoye (1986) used it for both P and K while 1M Ammonium acetate pH 7.0 (Schollenberger and Simon, 1945) is a multipurpose extractant used in the extraction of exchangeable bases (Na, K, Ca, Mg) and micronutrient such as Mn. The use of a multipurpose extractant such as the Mehlich-3 (Mehlich, 1984) affords soil chemists and commercial laboratories the luxury of extracting more than one element from the soil in their available form in one single extraction. However, M3 has not been evaluated and adapted for some Nigerian soils. Therefore having a multipurpose extractant for simultaneous extraction of P and K will be beneficial to rapid and routine analysis. Mehlich-3 is a modification of Mehlich-2 extractant to include Cu among the extractable nutrients, retain or enhance the wide range of soils for which it is suitable and minimize its corrosive properties.

The objectives of this study therefore are to: compare single and multipurpose extractants of P and K including Mehlich-3; relate Mehlich-3extracted soil P and K to P and K uptake of bell pepper.

Materials and Methods

Thirty six (36) composite purposively selected surface soil samples (0 – 15 cm) belonging to eight soil series and two soil orders (Alfisols and Ultisols) from 12 locations across three agro-ecological zones of Nigeria were collected. The soil series were Egbeda, Apomu and Jago from Ibadan, Alagba, Afia Mkpo, Ugbolu and Oji from Mbato, and Gadau from Bagauda. The locations were at the National Horticultural Research Institute (NIHORT) headquarters, Ibadan, Oyo State (Derived Savannah zone) and its substations at Mbato, Imo State (Humid forestzone) and Bagauda in Kano State (Northern Guinea Savannah zone) as shown in Fig.1. The soils were taken from three locations in each of the agro-ecological zones based on land use and vegetation cover.

Location 1 – Derived savannah zone, Ibadan, Oyo State

Location 2 - Northern Guinea savannah, Bagauda, Kano State

Location 3 – Humid Forest zone, Mbato, Imo State

Available phosphorus was determined using; Bray 1: 0.03N $NH_4.F$ + 0.025N HCl (Bray and Kurtz, 1945), Bray 2: 0.03N $NH_4.F$ + 0.10N HCl (Bray and Kurtz, 1945), Olsen P: 0.5M $NaHCO_3$ (Olsen *et al*., 1954), Mehlich-3: 0.2M CH_3COOH + 0.25M NH_4NO_3 + 0.015M NH_4F + 0.013M HNO_3 + 0.001M EDTA (Mehlich, 1984), Ammonium hydrogen fluoride extractanct: 0.05M NH4F.HF + 0.01M DTPA (Adeoye, 1986) and Modified Mehlich-3 (substituted EDTA with DTPA): 0.2M CH_3COOH + 0.25M NH_4NO_3 + 0.015M NH_4F + 0.013M HNO_3 + 0.001M DTPA.

Exchangeable potassium was determined using; 1M Ammonium acetate pH 7.0 (Black, 1965), Mehlich-3: 0.2M CH_3COOH + 0.25M NH_4NO_3 + 0.015M NH_4F + 0.013M HNO_3 + 0.001M EDTA (Mehlich, 1984), Ammonium hydrogen flouride extractant: 0.05M NH4F.HF + 0.01M DTPA (Adeoye, 1986) and modified Mehlich-3 (substituted EDTA with DTPA)): 0.2M CH_3COOH + 0.25M NH_4NO_3 + 0.015M NH_4F + 0.013M HNO_3 + 0.001M DTPA.

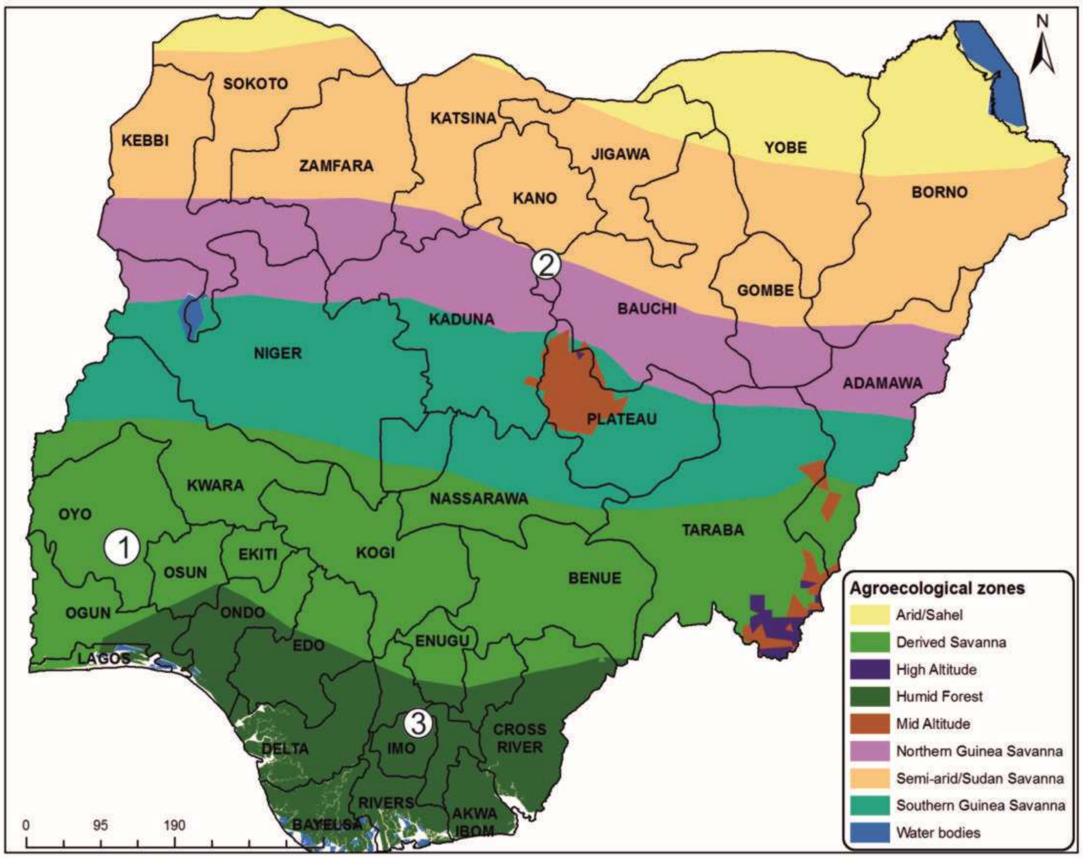

Fig 1: Map of Nigeria showing the agro-ecological zones (IITA, 2015) where soil samples were taken for correlation and screenhouse studies.

Diethylenetriaminepentaacetic acid (DTPA) was substituted for EDTA in the modified Mehlich-3 extractant because of the ability of DTPA to extract nutrients without the destruction of the carbonate. For Bray P-1 and P-2, NH_4F.HF, Mehlich-3 and modified Mehlich-3 tests, 1 g of soil was extracted with 10 ml of the extractants (ratio 1:10) on a reciprocating shaker for five minutes, while for Olsen, 1 g of soil was extracted with 20 ml of the extractant (ratio 1:20) and shaken for 30 minutes. All extracts were filtered through Whatman No. 42 filter paper. About 5 ml aliquot of the extracts were taken into 25 ml volumetric flask, 5 ml of Ascorbic acid (Watanabe and Olsen, 1965) was added, shaken and made to mark with distilled water. In the screen house, three kilogram soils were weighed into perforated plastic pots lined with tissue paper with trays at the bottom of the pot. Soils from each location were replicated three times in a completely randomized design (CRD). Bell pepper seeds (var. California Wonder) were raised in the nursery for four weeks before transplanting into the pots. The pots were watered to field capacity and allowed to equilibrate for 48 hours before transplanting. Two seedlings of the test crop were transplanted per pot and thinned to one after one week. Nitrogen fertiliser (Urea) at 40 kg N/ha was applied in a single dose one week after transplanting (WAT). Whole bell pepper plants were harvested at 4 WAT, packed into well labelled envelopes, oven dried at 75 ^{0}C to constant weight and weighed for their dry matter yield. Oven dried plant samples were blended and analysed for their P and K contents. Plant samples were analysed for their P and K contents according to the procedure outlined in Selected Methods for Soil and Plant Analysis Manual of International Institute of Tropical Agriculture, Ibadan (IITA, 1979). Total phosphorus was determined by vanadomolybdate yellow colorimetric method (A.O.A.C, 1970) while K was determined by Flame Photometry method.

Nutrient uptake was calculated as shown below;

$$\text{Nutrient uptake (g/kg)} = \text{content in plant tissue (g/kg)} \times \text{dry matter yield (g/kg)}$$

Extracted P, K and nutrient uptake values obtained from laboratory soil extractions and nutrient uptake determination respectively were subjected to statistical analysis using SAS 9.0 to determine the relationships and significant differences between extractants as well as between extractants and uptakes.

Results and Discussion

The values of P extracted by different extractants across all locations are shown in Table 1, the means, sd, cv and the range values are shown in Table 2.

Table 1: Phosphorus (mg/kg) extracted in the pre-planting soils of the three agro-ecological zones

Soil	Bray 1	Bray 2	Olsen	Mehlich-3	NH_4.HF+DTPA	Modified Mehlich-3
Ibadan						
1	13.76	9.54	5.22	14.58	22.50	18.75
2	13.44	31.97	20.15	47.25	45.00	51.00
3	4.30	5.40	0.58	2.70	11.25	9.00
4	9.56	9.50	5.94	12.15	22.50	18.13
Bagauda						
5	5.11	7.97	2.54	2.97	10.00	9.75
6	7.56	7.29	2.36	7.83	13.75	11.25
7	8.58	14.63	5.22	9.18	12.50	9.75
8	9.35	5.90	5.94	6.48	17.50	11.25
Mbato						
9	15.89	27.00	11.93	43.47	42.50	33.00
10	5.50	7.02	0.61	10.26	16.25	10.50
11	3.32	4.37	0.21	11.34	12.50	10.50
12	3.75	3.42	0.58	4.65	7.50	6.00

Table 2: Means and range of extracted available P.

Extractants	Mean (mg/kg)	sd	cv (%)	S.E	Range (mg/kg)
Bray P1	8.34	4.23	0.51	1.22	3.32 - 13.76
Bray P2	11.19	9.08	0.81	2.62	3.72 - 31.97
Olsen	5.11	5.83	1.14	1.68	0.21 - 20.15
Mehlich-3	14.41	14.93	1.04	4.32	2.97 - 47. 25
$NH_4F.F$ + DTPA	30.33	14.93	0.49	4.32	7.5 - 45.0
Modified Mehlich-3	15.68	12.04	0.77	3.48	7.7 - 43.13

sd = standard deviation cv = co-efficient of variation S.E. = standard error

Table 3 shows the correlation coefficient (r) among P extractants. The mean value of P extracted by Bray P1 extractant across all locations was 8.34 mg/kg and ranged between 3.32 and 13.76 mg/kg while P extracted by Bray P2 extractant ranged between 3.72 and 31.97 mg/kg with a mean value of 11.19 mg/kg. The means of P extracted by Olsen and Mehlich-3 extractants were 5.11 and 14.41 mg/kg respectively while the values ranged between 0.21 to 20.15 mg/kg and 2.97 to 47.25 mg/kg respectively. Phosphorus values of soils extracted by $NH_4F.F$ + DTPA and Modified Mehlich-3 ranged between 7.5 to 45.0 mg/kg and 7.7 to 43.13 mg/kg respectively, while the means were 30.33 and 15.68 mg/kg respectively. There were significant correlations between P extracted by Mehlich-3 extractant and other conventional extractants of P ($\alpha_{0.01}$). Correlation coefficient (r) of the extractants ranged from 0.77 to 0.96 (Table 3).

Table 3: Correlation co-efficients (r) and conversion equations relating Mehlich-3 and other P extractants

Extractant	Correlation co-efficient (r)	Conversion equation from Mehlich-3 P values
Bray 1	0.77*	y(B1) = 0.4939x + 3.0351
Bray 2	0.95*	y(B2) = 0.5755x + 2.9027
Olsen	0.90*	y(O) = 0.3514x + 0.0442
Ammonium hydrogen flouride + DTPA	0.96*	y(ABD) = 0.7724x + 9.2022
Modified Mehlich-3	0.95*	y(MM3) = 0.7652x + 4.6547

*Significant at 5%

where x = values of P extracted by Mehlich-3 and y(B1) = Phosphorus extracted by Bray 1
y(B2) = Phosphorus extracted by Bray 2 y(O) = Phosphorus extracted by Olsen
y(ABD) = Phosphorus extracted by $NH_4F.F$ + DTPA y(MM3) = Phosphorus extracted by Modified Mehlich-3

Table 4: Potassium (cmol/kg) extracted by various K extractants in all locations.

Soil	Mehlich-3	Ammonium Acetate	NH_4.HF+DTPA	Modified Mehlich-3
Ibadan				
1	0.28	0.20	0.19	0.18
2	0.22	0.18	0.16	0.17
3	0.65	0.53	0.35	0.43
4	0.45	0.30	0.27	0.27
Bagauda				
5	0.92	0.78	0.39	0.59
6	1.10	0.96	0.14	0.66
7	1.00	0.76	0.22	0.52
8	0.70	0.55	0.14	0.43
Mbato				
9	0.24	0.16	0.12	0.18
10	0.58	0.50	0.21	0.36
11	0.58	0.45	0.20	0.33
12	0.38	0.30	0.18	0.24

The lowest correlation coefficient (r) of 0.77 was between Mehlich-3 and Bray P1 while the highest of 0.96 was between Mehlich-3 and $NH_4F.F$ + DTPA.

The values of K extracted by different extractants in all locations are shown in Table 4 while the means, sd, S.E, cv and the range values are shown in Table 5. The mean value of K extracted by 1M Ammonium Acetate pH 7.0 extractant across all locations was 0.47 cmol/kg of soil and ranged between 0.18 and 0.96 cmol/kg while values by Mehlich-3 extractant ranged between 0.22 and 1.10 cmol/kg with a mean value of 0.59 cmol/kg. The means of K extracted by $NH_4F.F$ + DTPA and Modified Mehlich-3 were 0.21 and 0.36 cmol/kg respectively while the values ranged between 0.12 to 0.39 cmol/kg and 0.17 to 0.66 cmol/kg respectively. There were significant correlations between K extracted by Mehlich-3, 1M Ammonium Acetate pH 7.0 and Modified Mehlich-3 extractants although there was no significant correlation between K extracted by Mehlich-3 and $NH_4F.F$ + DTPA. ($\alpha_{0.05}$). Table 6 shows the correlation coefficient (r) between K extracted by Mehlich-3 extractant and the other extractants of K and the conversion factors of K values from recommended extractants to M3 K values.

Table 5: Means and range of extracted exchangeable K (cmol/kg) across all sites.

Extractants	Mean (cmol/kg)	sd	cv(%)	S.E	Range (cmol/kg)
Ammonium Acetate pH 7.0	0.47	0.06	12.77	0.02	0.18 - 0.96
Mehlich-3	0.59	0.3	50.85	0.09	0.22 - 1.10
NH4F.F + DTPA	0.21	0.08	38.10	0.02	0.12 - 0.39
Modified Mehlich-3	0.36	0.17	47.22	0.05	0.17 - 0.66

sd = standard deviation cv = co-efficient of variation .E. = standard error

Table 6: Correlation co-efficients (r) and conversion equations relating Mehlich-3 and K extractants

Extractant	Correlation co-efficient (r)	Conversion equation from Mehlich-3 K values
1M Ammonium acetate pH 7.0	0.99*	y (AAc) = 0.8665x - 0.0402
Ammonium hydrogen flouride + DT	Ns	ns
Modified Mehlich-3	0.98*	y (MM3) = 0.5488x + 0.0386

* Significant at 5%, ns – not significant
where x = values of K extracted by Mehlich-3
and y(AAc) = Potassium extracted by 1M Ammonium acetate pH 7.0
y(MM3) = Potassium extracted by Modified Mehlich-3

Table 7: Means and range of P and K (g/kg) uptake by bell pepper.

Nutrient	Mean	sd	cv (%)	S.E	Range
P	2.34	1.74	74.36	0.50	1.15 - 6.12
K	22.62	7.88	34.84	2.28	12.80 - 35.78

sd – standard deviation cv – co-efficient of variation S.E. – standard error

Table 8: Correlation co-efficients (r) relating P uptake of bell pepper and amounts of P extracted by extractants

P extractant (mg/kg)	Correlation co-efficient (r)
Mehlich-3	0.95*
Bray P1	0.78*
Bray P2	0.89*
Olsen	0.85*
Ammonium hydrogen flouride + DTPA	0.89*
Modified Mehlich-3	0.95*

Table 9: Correlation co-efficients (r) relating K uptake of bell pepper and amounts of K extracted by extractants

K extractants (cmol/kg)	Correlation co-efficient (r)
Mehlich-3	0.95*
Ammonium Acetate pH 7.0	0.94*
Ammonium hydrogen flouride + DTPA	ns
Modified Mehlich-3	0.93*

The means and range of P and K uptake by bell pepper in soils from different locations are contained in Table 7. There were significant correlations between all P extractants and P uptake of bell pepper. Mean P uptake was 2.34 g/kg and ranges from 1.15 to 6.12 g/kg. Highest P uptake of 6.12 g/kg was observed on soil 5 while the lowest with a value of 1.15 g/kg was observed on soil 2. Table 8 shows the correlation coefficient (r) between P uptake by Mehlich-3 extractant and other extractants of P. The lowest correlation coefficient (r) of 0.78 was observed between P uptake and Bray P1 while the highest of 0.95 was with Mehlich-3. The lowest 'r' was with Olsen P and the highest with Modified Mehlich-3. There were significant correlations between all K extractants and K uptake of Bell Pepper except with NH4F.F + DTPA (Table 9). The lowest correlation coefficient (r) of 0.93 was observed between K uptake and Modified Mehlich-3 while the highest (0.95) was observed with Mehlich-3. Mean K uptake was 22.62 g/kg and ranged from 12.80 to 35.78 g/kg. Highest K uptake was 35.78 g/kg while the lowest was 12.80 g/kg. The highest and the lowest correlations were observed with Mehlich-3 and Modified Mehlich-3 respectively

DISCUSSION

Soils used for the studies belong to two soil orders of the Soil Survey Staff, 1990 and eight soil series. The soil orders are Alfisols in Ibadan and Mbato and Ultisols in Bagauda. There are wider variations among Ibadan and Mbato soil series, whereas only one soil series is identified in Bagauda location. The series in Ibadan (Derived Savannah zone) are Egbeda, Apomu and Jago, at Mbato (Humid Forest zone) they are Alagba, AfiaMkpo, Ugbolu and Oji soil series while Gadau soil series is the only one identified at Bagauda (Southern Guinea Savannah).

The pH range (4.0 - 6.3) of the soils explain the soil reactions with P extractants that determines the selection of P extractant on Nigerian soils, while values of 5.2 – 5.8 on sites used for calibration studies are well suited for Bell Pepper growth (Grubben and Denton, 2004). Observations from these studies showed that Mehlich-3 extracted P across soils of varying pH. The textural classes of the soils which are loamy sand, sandy loam and silt loam reflect the parent material from which the soils are formed. Organic Carbon content of the soils (2.33 – 33.33 g/kg) used for correlation studies reflects the cropping history of the sites. Soils with organic carbon content higher than 15.0 g/kg are from sites that have either been under fallow for some years or a plantation which resulted from accumulation of organic material over time, while the sites under continuous cropping had low organic carbon. The total nitrogen (TN) varying from low to high (0.19 – 2.90 g/kg) follows the same trend as in organic carbon. Highest TN was obtained in soils with highest organic carbon. The correlation between organic carbon and total nitrogen is a characteristic of mineral soils whose nitrogen source is mainly organic (Chude *et al*., 2011). Available P (Bray P1) with an average of 8.34 g/kg was generally below critical level of 15 mg/kg established by Adeoye (1986) for sedimentary soils of South West Nigeria, this probably could be as a result of P depletion due to continuous cultivation. The highest value of 15.89 g/kg is obtained in the soil collected from bounds between experimental plots, a location that is under continuous fallow which allows P build up and conservation. Exchangeable cations were moderate although the effective cation exchange capacity was low. Potassium levels of most of the soils were above the critical level of 0.20 cmol/kg (FMARD, 2004), probably due to K fertiliser application over time. The base saturation was generally high with soils from Mbato having the highest and Bagauda the lowest.

The significantly high coefficient (r) of 0.77 - 0.96 between P extractants and Mehlich-3 extractant are indications that P was extracted from the same pool by all the extractants which suggests that it is a suitable extractant. Phosphorus extracted by Mehlich-3 was not affected by the pH of the soil which was a limitation and disadvantage of recommended extractants. Mallarino and Atia

(2005) discovered that soil P measured by Bray extractants were less in $CaCO_3$-affected soil with pH ≥ 8.1 but not when pH was ≤ 7.7. Beegle and Oravec (1990) also, *reported high correlations of Mehlich-3 extractant with Bray1 (r=0.99) and* neutral 1M ammonium acetate K extractant (r=0.96).

The lowest correlation of 0.77 was between Mehlich-3 and Bray P1 while the highest (0.96) was between Mehlich-3 and $NH_4F.F$ + DTPA. This corroborates the assertions of Adeoye (1986) who identified 0.1M $NH_4F.HF$ + 0.005M DTPA (unbuffered) as the best multipurpose extractant suitable for simultaneous extraction of P, K, Mg, Zn and Mn. Although there were significant correlations among all the extractants of P, the difference in the amount of P extracted could be attributed to the pH of the extractants and species of ions present. Higher amount of P extracted by Bray P2 than P1 may be due to the lower pH of Bray P2. The influence of chemical composition of Bray P solutions on P extraction may be due to the fact that acid fluoride and chlorides are effective in extracting Al and Fe bound P which is predominant in the top horizons of sedimentary soils of South West Nigeria as observed by Uzu (1973). On the other hand, the different amounts of P extracted by Bray 1, M3 and MM3 despite similar pH is most likely to be due to the species of ions present in the extractants while the difference in pH and ionic composition may be responsible for amount of P extracted by Olsen. Observations showed that EDTA and DTPA chelates actively participated in P extraction, because highest amounts of extracted P were observed with extractants containing either EDTA or DTPA.

Correlation coefficients (r) relating Mehlich-3 and other K extractants were significantly high except with $NH_4F.HF$ + DTPA (ABD) which were not significant and negative implying that it is not a suitable extractant for K. Although Adeoye (1986) identified 0.1M $NH_4F.HF$ + 0.005M DTPA (unbuffered) as best multipurpose extractant suitable for simultaneous extraction of P, K, Mg, Zn and Mn, observation from this study showed otherwise, probably because Adeoye worked on sedimentary soils of South West Nigeria which is different from Basement complex where this investigation was carried out. The r value of 0.99 between Mehlich - 3 and 1M Ammonium Acetate pH 7.0 - the only recommended extractant for K was quite high and made Mehlich-3 as suitable as 1M Ammonium Acetate pH 7.0 extractant across the soils. Correlation coefficient (r) of 0.78 - 0.95 between P extractants and P uptake of bell pepper were significantly high. Highest "r" of 0.95 observed with Mehlich - 3 is an indication that M3 extract P from soil solution in the same way bell pepper root absorbed P. Prediction of P uptake at a given soil test level of P is thus possible because of the direct relationship between them.

The correlation coefficient between K uptake and K extractants are significantly high except for NH4F.F + DTPA (ABD). The r value of 0.95 observed between Mehlich-3 and K uptake of bell pepper showed that Mehlich-3 absorbed K in the same way as the roots of bell pepper indicating the suitability of Mehlich - 3 as a K extractant across soils of varying chemical properties. Phosphorus and K soil test values extracted by Mehlich-3 could also be converted to corresponding values of P and K extracted by recommended extractants through the conversion equations derived.

CONCLUSION

There were significant correlations among extractants and between extractants and nutrient uptake values. Correlation coefficient (r) between M3 extracted P values and values extracted by other P extractants across all soils ($\alpha_{0.01}$) were positive and high. The values ranged from 0.77 to 0.96. The lowest value was observed in respect of the extraction by BP1 while the highest was observed with

ABDP. The r values of the relationship between M3 extracted K values and amounts extracted by other K extractants were also significant ($\alpha_{0.01}$) across all soils except for ABD.
There were significant correlations between P uptake values by bell pepper and M3, B1, B2, O, ABD as well as MM3 extracted P ($p < 0.01$). The values were 0.95, 0.78, 0.88, 0.85, 0.90 and 0.96 respectively. Correlations were also significant between K uptake by bell pepper and the amount of K extracted by the various extractants except for ABD. Correlation coefficient values ranged from 0.93 in MM3 to 0.95 in ABD. Correlation coefficients (r) relating M3 and other conventional P extractants across the soils were significant. Furthermore, correlation relating Mehlich - 3 extracted soil P and P uptake by bell pepper was also significant. Correlation coefficients (r) obtained by relating M3 and other conventional K extractants were also significantly high, except for Ammonium hydrogen flouride + DTPA (ABD). The correlation between Mehlich - 3 extracted soil K and K uptake of bell pepper was also significantly high except for Ammonium hydrogen flouride + DTPA (ABD). Observations and indications from these relationships is that M3 is a suitable multipurpose extractant that could be used as substitute for the recommended P and K extractants.
Mehlich-3 is a suitable extractant for estimating soil available phosphorus and exchangeable K for the purpose of predicting response to fertiliser application and for advisory P and K fertiliser recommendation for bell pepper.

Recommendations

Mehlich-3 extractant is suitable for extraction of available phosphorus and exchangeable potassium and thus is capable of ascertaining the deficiency or sufficiency of the two nutrients in the soils. It is recommended for the extraction of phosphorus and potassium from the soils as it will make their extraction faster, easier, and cheaper and in ascertaining response of crops to fertiliser application.

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