Evaluation of Three Universal Extractants for the Determination of P, NO_3^- and K in Some Soils of Ethiopia

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Abstract

The objective of this study was to assess the effectiveness of selected universal soil extractants (0.01 M $CaCl_2.2H_2O$, 0.01 M $BaCl_2$, 0.02 M $SrCl_2.6H_2O$) procedures on extraction efficiency of the extractants for the determination of P, NO_3^- and K. The study was conducted using completely randomized design method in three replications at Haramaya University Laboratory by collecting five (5) soil samples from Bako, Ambo, Awash, Metehara and Amaresa. From the results obtained, 0.02 M $SrCl_2.6H_2O$ extraction procedure was found to be the most suitable method for the determination of P in acidic, basic and neutral soils. However, very close relationship was found between this extractant and conventional soil testing method for P with ($p<0.01$ and $r = 0.997$). The amount of nitrate determined by 0.02 M $SrCl_2.6H_2O$ was higher than the other extractants used in this study and this extractant was found to be the most suitable extractant for the determination of nitrate in basic soils and also very close relationship was found between this extractant and conventional soil testing method with ($p < 0.01$ and $r = 0.991$). On the other hand the amount of nitrate determined by 0.01 M $BaCl_2$ was found to be the most suitable for acidic and neutral soils and also very close relationship was found between this extractant and conventional soil testing method with ($p<0.01$ and $r = 0.989$). The amount of K determined by conventional soil testing method was higher than unbuffered salt extractants used in this study. However, very close relationship was found between 0.01 M $BaCl_2$ extractable K and 1M ammonium acetate extractable K with ($p <0.01$ $r = 0.997$). Although very close relationship was found between the amount of NO_3^-, P and K extracted by unbuffered salt solutions and conventional soil testing method, the t-test indicates that the two methods are significantly different (at $p < 0.05$). Thus, these unbuffered salt solutions could easily be adopted for the determination of P and NO_3^- in the soil. But for the determination of K in the soil, the unbuffered salt solution could not replace the conventional soil testing method.

Key words: soils, universal extractants, P, NO_3^-, K, availability

1. Introduction

The term universal soil extractant has been used to name reagents or procedure to evaluate several elements and ions from a soil to find out fertility status and/or metal toxicity (Abreu *et al*.1994). The main problem in the use of single extraction methods lies in the lack of uniformity in the different procedures used. In consequence, the results obtained are operationally designed depending on the experimental conditions used (type and concentration of extracting agent, soil mass to volume ratio, shaking time and speed of shaking) (Pueyo *et al.* 2004). Soils are highly variable and complex and developing single extraction method specific to the soil of interest makes the job expensive and time consuming. Therefore developing a universal extractant that does an acceptable job of accuracy in identifying plant available nutrient is required (Haney *et al*.2006).

Extraction of nutrients by unbuffered salts such as $CaCl_2$, $BaCl_2$, $SrCl_2$ and $SrCl_2$-citrate are rapid and simple way to evaluate their phytoavailability. Recently, the use of 0.02 M strontium chloride as a universal extractant for predominantly calcareous soils was reported (Li *et al*. 2006). They suggested that this extractant was more efficient than the already established universal extractant (0.02 M $SrCl_2$-0.05 M citrate).

Information related to the use of these unbuffered universal extractants ($CaCl_2$, $BaCl_2$, $SrCl_2$) in Ethiopian soil is scarce and the purpose of this work is to assess the effectiveness of these extractants for soils of selected pH. This study will also focus on relationships between the conventional soil testing methodologies for P, NO_3^- and K and the universal extractants proposed.

2. Materials and methods

2.1. Description of the study Area

The study was conducted by collecting five soil samples from different parts of Ethiopia. These areas were selected purposively. The selected sites were Amaresa, Ambo, Awash, Bako and Metehara. Ambo was located with an altitude of 2090masl, latitude 08^0 58' N and longitude 37^0 53' E. Amaressa was located with an altitude of 1950masl, a hilly land form with coordinates, latitude 09^0 19' N and longitude 42^0 06' E. Bako was located with an altitude of 1850masl, latitude 09^0 07' N and longitude 37^0 03'E. Metehara was located with an altitude of 1650masl, latitude 08^0 29' N and longitude 39^0 13' E. Awash was found in Afar regional state of Ethiopia with an altitude of 850masl, latitude 9^0 16' N latitude and longitude 40^0 9' E (Eyilachew 1993).

2.2. Experimental Design

The study was conducted in three treatments (0.01 M $CaCl_2.2H_2O$, 0.01 M $BaCl_2$, 0.02 M $SrCl_2.6H_2O$) with three replications in completely randomized design (CRD) at Haramaya University Laboratory.

2.3. Soil Sampling

Composite surface soil samples (0-20 cm depth) were collected randomly in zigzag pattern from six sampling spots of the experimental site before determination of some selected physico-chemical properties of the soil.

2.4. Laboratory Analyses

The collected soil samples were allowed to air dry at room temperature and ground to pass through a 2 mm sieve. Soil pH (H_2O) was determined in 1:2.5 soil water suspension using glass electrode pH meter (model RS 232) (Van Reeuwijk 1992). Soil pH (KCl) was determined by dispersing 10 gram of soil in 25 ml of 1M KCl after 2 hr shaking at 20 rpm with Orbital shaker (model SO1) (Freese *et al*. 1995). The texture of the soil was determined by the hydrometer method after dispersion of the soil with sodium hexameta phosphate (Day 1965) The calcium carbonate content of the soil was determined by acid neutralization method by treating the soil sample with standard HCl (Jackson 1970) . Organic carbon of the soil was determined by using Walkely and Black method by dichromate oxidation technique (Neilson et al. 1982). Cation exchange capacity of the soil was determined from ammonium acetate saturated samples through distillation and measuring the ammonium using the modified Kjeldahl procedure as described by (Bremer *et al*. 1982).

2.5. Soil Analyses

For conventional soil testing method, available phosphorus for alkaline soils were determined using the methods described by (Olsen *et al*. 1982) and from acidic to neutral soils available phosphorus were determined by using Bray and Kurtz (Bray 1) (Bray *et al*.1945). Potassium in the soil sample was determined by using 1 M ammonium acetate method and nitrate nitrogen was determined by using 1 M KCl.

For the universal extractants, all the samples were analyzed using 0.01 M $CaCl_2$. $2H_2O$, 0.02 M $SrCl_2.6\ H_2O$ and 0.01 M $BaCl_2$ extractants and filtrated using whatman filter paper (540, 90 mm diameter).

P in soil solution was colorimetrically determined by using Riley and Murphy method using ascorbic acid as reductant with UV- Visible spectrophotometer at 712 nm wavelength (Murphy *et al*. 1962).

Soil nitrate was determined colorimetrically by using phenoldisulfonic acid and the analysis was carried out using UV- Visible spectrophotometer at 415 nm. (Jackson 1958). Potassium (K) was determined by using flame photometer (Kundsen *et al*.1982).

For all the samples and extractants analysis were carried out with a soil solution ratio (m: v) of 1g: 10 ml and 30 minutes of continuous shaking by using orbital shaker. Analysis of the same soil with the same extractant was triplicated. During the experiment when the solution appeared turbid or when there was precipitation on the bottom of the flask, the solution was left standing to let the suspended particles settle (5 minute) and the clean solution was used for analysis, (Li *et al*. 2006) and (Carter 1993).

3. Results and discussion

3.1. Soil Physico chemical properties

Physicochemical properties of soil samples were analyzed in (Table 1). Soil analysis of the experimental sites showed that the soil samples were in the pH range between 5.72 and 8.4. According to (Murphy *et al*. 1962) soils with a pH range between 5.6-6 are moderately acidic, soils with a pH range between 6.1- 6.5 are slightly acidic, soils with a pH range between 6.6-7.4 are neutral or nearly neutral, soils with a pH range of 7.4-7.8 are slightly alkaline, soils with a pH range between 7.4-8.4 are moderately alkaline and soils with a pH above 8.5 are strongly alkaline. Based on this classification, the soil sample collected from Bako is moderately acidic, soil sample collected from Amaresa is slightly acidic, soil sample collected from Ambo is neutral, soil sample collected from Awash is slightly alkaline and soil sample collected from Metehara is moderately alkaline.

The cation exchange capacity of the soil ranged from 13 cmol. (+) kg^{-1} (Awash) to 25 cmol. (+) kg^{-1} (Ambo). The cation exchange capacity of the soil is strongly affected by the amount and type of clay and the amount of organic matter present in the soil. Soils with large amounts of clay and organic matter have higher cation exchange capacity than sandy soils which have low organic matter.

The calcium carbonate content of the soil was high in Metehara which is 4.6% and low in Awash which is 3.7%. Acidic and neutral soils under studied area showed no detectable amount of calcium carbonate.

The organic carbon content of the soil samples were ranged from 0.04% in Amaresa to 1.84% Ambo. The low OC in Amaresa soil is probably due to high amount of sand in the soil.

Soil samples collected from Awash and Bako contain large amount of sand (52%) and soil samples collected from Ambo contains small amount of sand (32%). The clay content of the soil samples ranged from 5% (Awash) to 35 % (Ambo and Amaresa). The silt content of the soil samples ranged from 9% (Bako) to 43 % (Awash).

3.2. Extractable P, NO_3^- and K (mg/ kg) in conventional soil testing method

The amount of P extracted by conventional soil testing method ranged from 1.5 mg kg^{-1}(Amaresa) to 39.96 mg kg^{-1}(Ambo). The amount of NO_3^- extracted ranged from 0.99 mg kg^{-1} (Amaresa) to 3.36 mg kg^{-1}(Metehara) and the amount of K extracted ranged from 75.12 mg kg^{-1} (Amaresa) to 394.6 mg kg^{-1}(Metehara) (Table 2).

3.3. Extractable P, NO_3^- and K concentrations (mg/kg) in the soils studied after applying the three universal extractants extraction procedures

The amount of P extracted by 0.02 M $SrCl_2.6\ H_2O$ ranged from 2.48 mg kg^{-1} (Amaresa) to 62 mg kg^{-1} (Ambo). The amount of P extracted by 0.01M $CaCl_2.2H_2O$ ranged from 1.89 mg kg^{-1} (Amaresa) to 50.6 mg kg^{-1} (Ambo) and the amount of P extracted by 0.01 M $BaCl_2$ ranged from 2.03 mg kg^{-1} (Amaresa) to 56.76 mg kg^{-1} (Ambo). Furthermore, the amount of NO_3^- extracted by 0.02 M $SrCl_2.6\ H_2O$ ranged from 2.7 mg kg^{-1} (Amaresa) to 12.3 mg kg^{-1} (Metehara). The amount of NO_3^- extracted by 0.01M $CaCl_2.2H_2O$ ranged from1.54 mg kg^{-}(Amaresa) to 9.9 mg kg^{-1} (Metehara) and the amount of NO_3^- extracted by 0.01 M $BaCl_2$ ranged from 2.85 mg kg^{-1} (Amaresa) to 8.63 mg kg^{-1} (Metehara) and the amount of K extracted by 0.02 M $SrCl_2.6\ H_2O$ ranged from 55.28 mg kg^{-1} (Amaresa) to 327 mg kg^{-1} (Metehara). The amount of K extracted by 0.01M $CaCl_2.2H_2O$ ranged from 35.9 mg kg^{-} (Amaresa) to 221.4 mg kg^{-1} (Metehara) and the amount of K extracted by 0.01 M $BaCl_2$ ranged from 56.8 mg kg^{-1} (Amaresa) to 350.6 mg kg^{-1} (Metehara) (Table 3).

3.4. Analysis of Variance with equal replication of P, NO_3^- and K extracted by 0.02 M $SrCl_2.6H_2O$, 0.01 M $CaCl_2.2H_2O$ and 0.01 M $BaCl_2$

As shown in Table 4, analysis of variance indicates that the methods are highly significant in all soil samples. Based on this, 0.02M $SrCl_2.6\ H_2O$ was found to be the most suitable extractant for the determination of P in all soil samples. The relatively lower amount of extractable P in $CaCl_2$ solution could be attributed partly to the possible enhancement of Ca^{2+} on P sorption by soils. However, Very close relationship was observed between these measurements $r \geq 0.991$.

It was also shown in Table 4, analysis of variance indicates that the amount of NO_3^- extracted by these methods was found to be highly significant in all soil samples. Based on this result, 0.02M $SrCl_2.6\ H_2O$ was found to be the most suitable extractant for the determination of NO_3^- in basic soils and 0.01 M $BaCl_2$ in acidic and neutral soils. This could be attributed to the nature of availability of NO_3^- ion in soil solution. Nitrate ion remains in soil solution and simple exchange or leaching could be enough to effect the extraction. However, Very close relationship was found between these measurements with $r \geq 0.991$

As shown in Table 4, analysis of variance indicates that the amount of K extracted by these extractants is found to be highly significant in all soil samples. The amount of K extracted followed the order $BaCl_2$ > SrCl2 > CaCl2. This is consistent with the hydrated radii of the cations. The smaller the hydrated cation radius, the faster the mobility of the ion in soil solution. That is why barium is found to be the most robust in exchanging cations such as K from the soil. However, very close relationships were observed between $BaCl_2$, SrCl2 and CaCl2 extractable K ($r \geq 0.942$).

3.5. Results of t- test between conventional and universal extractants for determination of P, NO_3^- and K.

In general close relationship was observed between conventional soil testing method and universal extractants ($r \geq 0.996$) as evidenced by the t-test shown in Table 5. This statistically significant correlation was observed across all soil samples considered in this study for extractants 0.02 M $SrCl_2.6H_2O$ and 0.01 M $BaCl_2$ ($p < 0.05$). The extractant 0.01 M $CaCl_2.6H2O$, however showed significant correlation only for moderately acidic and neutral soils, ($p<0.05$). This indicates that 0.02 M $SrCl_2.6H_2O$ and 0.01 M $BaCl_2$ could easily replace the conventional soil testing method for P determination. Furthermore, 0.01 M $CaCl_2.2H2O$ could replace conventional soil testing method in moderately acidic and neutral soils.

Very close relationships were also observed between conventional soil testing method and universal extractants ($r \geq 0.990$) for nitrate determination. This correlation is found to be statistically significant ($p < 0.05$) (Table 6) for all soil samples for the determination of nitrate in all extractants except the case of 0.01 M $CaCl_2.2H_2O$ observed in Amaresa soil sample. These results reveal that 0.02 M $SrCl_2.6H_2O$, 0.01 M $BaCl_2$ and 0.01 M $CaCl_2.6H2O$ could replace conventional soil testing method for determination of nitrate in soil with the exception of the case stated above.

Furthermore, very close relationships were observed between conventional soil testing method and universal extractants ($r \geq 0.944$) for K determination. The amount of K determined by 0.02 M $SrCl_2.6H_2O$, 0.01 M $BaCl_2$ and 0.01 M $CaCl_2.6H2O$ were significantly different from conventional soil testing method in all soil samples ($p < 0.05$) (Table 7). The amounts of K extracted by these universal extractants were lower than the conventional soil testing method. This is due to the fact that the ammonium cation is approximately the same size as K ion (0.14nm and 0.13 nm respectively) so that it can easily fit the inter layer space of K and easily removes the large portion of K from the soil. This result was inconsistent to the report made by Hossenipur and Samavati, (2008) but consistent to the report made by other researchers (Sudhakumari *et. al*. 1994, Rao 2005, Li *et al*. 2006).

4. Conclusions

The findings of this study revealed that among the universal extractants (0.02 M $SrCl_2.6\ H_2O$, 0.01 M $CaCl_2$. $2H_2O$ and 0.01 M $BaCl_2$) that were tested for the determination of available P, 0.02 M $SrCl_2.6\ H_2O$ was the most effective in acidic, neutral and basic soil. Furthermore 0.02 M $SrCl_2.6\ H_2O$ and 0.01 M $BaCl_2$ could replace conventional soil testing method for available P in all types of soils and 0.01 M $CaCl_2$. $2H_2O$ could replace conventional soil testing method in moderately acidic and neutral soils.

Among the universal extractants (0.02 M $SrCl_2.6\ H_2O$, 0.01 M $CaCl_2$. $2H_2O$ and 0.01 M $BaCl_2$) tested for the determination of NO_3^-, 0.01 M $BaCl_2$ was the most effective in acidic and neutral soils and 0.02 M $SrCl_2.6\ H_2O$ was most effective for basic soil. Moreover, 0.02 M $SrCl_2.6\ H_2O$, 0.01 M $CaCl_2$. $2H_2O$ and 0.01 M $BaCl_2$ could replace conventional soil testing method for the determination of nitrate in all soil samples except 0.01 M $CaCl_2$. $2H_2O$, which was non significant for neutral soils.

The amount of K extracted by 0.02 M $SrCl_2.6\ H_2O$, 0.01 M $CaCl_2$. $2H_2O$ and 0.01 M $BaCl_2$ were lower than conventional soil testing method. Unbuffered extractants considered in this study may not be as effective extractant as the conventional when single nutrient extraction is considered.

References

Abreu, C.A., Abreu, M.F., Raij, B.V., Bataglia, O.C.(1994), “ Extraction of Boron from soil by microwave heating for ICP-AES determination”, *Commun. Soil Sci. Plant Anal*., 25:3321–3333.

Beckett,P.H.T.(1989), “The use of extractants in studies on trace metals in soils, sewage sludge and sludge treated soils”, *Adv. Soil Sci*., 9:143-176.

Bray, R.H., and Kurtz, L.T.(1945), “Determination of total, organic and available forms of phosphorus in soils”. *Soil Sci*., 59:39-45.

Bremner, G.M. and C.S. Mulvaney, C.S.(1952), “ Nitrogen Total”, Prentice Hall, Inc., pp. 95-624.

M.R. Carter, M.R.(1993),“ Soil Sampling and Methods of Analysis”, Canadian Society of Soil Sci., Lewis Publisher., pp. 51-60.

Day,P.R.(1965), “Particle fractionation and particle size analysis”, Pages 545-567 in methods of soil analysis, C.A. Bl;ack, ed. Agronomy No 9, part I. American Society of Agronomy, Madison, WI.

Eyilachew, Z.(1993), “ Report on site profile description, physical and chemical properties of soil monoliths collected for soil reference”, National Soil Service Project, FAO/87/010. Ministry of Natural Resources Development and Environmental protection.

Esnaola, M.V., Bermond, A., Millan, E.(2000), “Optimization of DTPA and calcium chloride extractants for assessing extractable metal fractions in polluted soils”, *Commun. Soil Sci. Plant Anal*., 31:13-29.

Ferrier,G.B., Fontes, R.L.F., Fontes, M.P.F. and V.H.A.Venegas, V.H.A.(2001), “Comparing cadmium chloride, barium chloride and hot water extractions and testing activated charcoal plus azomethine-H dosage for boron determination in Brazilian soils”, *Commun. Soil Sci. Plant Anal*., 32:3153-3167.

Freese, D.R., Lookman,R., Merckx and Riemsdijk, W.H.(1995), “New method for long term phosphate desorption from soils”, *Soil Sci. Soc. Am. J*., 59:1295-1300.

R.L. Haney, R.L., E.B. Haney,E.B., L.R. Hossner, L.R. and J.G. Arnold,J.G.(2006), “Development of a new soil extractant for simultaneous phosphorus, ammonium and nitrate analysis”, *Commun. Soil Sci. Plant Anal*., 37: 1511-1523.

Holford,I.C.R.(1980), “ Green house evaluation of four phosphorus soil tests in relation to phosphate buffering and labile phosphate in soil”, *Soil Sci. Soc.American J*., 44: 555-559.

Hosseinpur, A.R.M., Samavati,(2008),“Evaluation of chemical extractants for the deytermination of available K”, *Commun. Soil Sci. Plant ana.* 39:1559-1570.

Houba,V.J.G., Van der Lee, J.J. and Novozamski, I.(1996), “Soil analysis procedures”, Dep. Of Soil Sci. plant nitrition. Landbouwu university, Wageningen Agric. Univ.

Jackson,M.L.(1958) ,“Soil Chemical Analysis”, Prentice –Hall Inc. Englewood Cliffs, NJ.

Jackson, M.L.(1970), “Soil Chemical Analysis”, Prentice –Hall Inc. Englewood Cliffs, N. Sixth printing, 498p.

Jones ,J.Jr.(1990), “ Universal soil extractants, their composition and use”, *Commun. Soil Sci. Plant Anal*., 21: 1091-1101.

Jones,J.R.(1998), “Soil test methods. Past, present and future use of soil extractants”, *Commun. Soil Sci. Plant Ana*l., 29: 1543-1552.

Knudsen, D., Petersen, G.A., and Pratt, P.F.(1982), “ Li, Na and K”, In: Methods of Soil Analysis, part 2, Chemical and Biological Properties, 2nd edition, A.L. (ed.). Soil Sci. Society of America, Madison, Wisconsin, pp. 225-246.

Li, L., Zhank, J., Xing,W., Cheu,W., Wu, X. and Zhu,K.(2006), “ Development and validation of new soil universal extractant”, *Commun. Soil Sci. Plant Anal*., 37:1627-1638.

Lindsay,W.L. and Norvell, W.A.(1978),“Development of DTPA soil test for zinc, iron, manganese and copper”, *Soil Sci. Soc .Am. J*., 42: 421.

Mehlich,A.1984(1984), “Mehilich 3 soil test extractant, a modification of the Mehilich 2 extractant”, *Commun. Soil Sci. Plant analysis,*15:1409.

Morgan,M.F.(1941), “Chemical soil diagnosisby the universal soil testing system”, Conn. Agri. Exp. Stn. Bull. No. 450.

Murphy,J. and Riley,J.P.(1962), “ A modified single solution method for the determination of phosphate in natural water”, *Anal. Chem. Acta*., 27: 31-36.

Neilson,D.W. and Sommers, I.E.(1982), “Total carbon,organic carbon,and organic matter, chemical and microbiological properties”, *Amer. Soc. Of Agron. J*., 9: 639-679.

Olsen, S.R. and L.E., Sommer, L.E.(1982), “Phosphorus”, in “ Page,A.L., Miller, R.H. and Keeneys, D.R. (eds.). Method of Soil Analysis. Chemical and Biological Properties”, *American Society of Agronomy*, 9: 403-430.

Pueyo,M., Lopez Semchez,J.F. and Rauret, G.(2004),“Assessment of $CaCl_2$, $NaNO_3$ and NH_4NO_3 extraction procedures for the study of Cd, Cu, Pb and Zn extractability in contaminated soils”, *Anal. Chem. Acta*, 504: 217-226.

Raij,B.V., Quaggio, J.A. and Silva,N.M.(1986), “Extraction of phosphorus, potassium, and magnesium from soil by an ion exchange procedure”, *Commun. Soil Sci. Plant Anal*, 17: 547-566.

Rao, D.V.(2005), “Evaluation of soil extractants in terms of growth”, *Commun. Soil Sci. Plant Anal.,* 36: 1513-1523.

Soltanpour, P.N. and A.P. Schwab, A.P.(1977), “A new soil test for simultaneous extraction of macro and micro nutrients in alkaline soils”, *Commun. Soil Sci. Plant Anal,* 8:195-207

Sudhakumar,B., Karthikakattyamma, M., Joseph, M. and Mathew,(1994), “Evaluation of two extractants of available K, Ca and Mg in acid soils under rubber”, *Indian J. Nat. Rubber Resource*, 7(2): 103-106.

Van Eng, P.J., Houba,V.J.G., Reijneveld, J.A. and Van Beusichem,M.L.(2001), “Relationship between magnesium extracted by 0.01M calcium chloride extraction procedure and conventional procedures”, *Commun. Soil Sci. Plant Anal*., 32: 1-18.

Van Reeuwijk,L.P.(1992), “Procedures for Soil Analysis”, 3rd ed. International Soil Reference and Information Center (ISRIC) , Wageningen, the Netherlands, 34p.

Wolf, B.(1982), "An improved universal extracting solution and its use for diagnosing soil fertility", *Commun. Soil Sci. Plant Anal*., 13:1005-1033.

Table 1. Characteristics of the soil samples[a]

Site	pH (H_2O)	pH (KCl)	$CaCO_3$ %	CEC c mol. (+) /kg	Organic C %	Texture % Sand	Silt	clay
Bako	5.72	4.56	-	20	0.09	*52*	*29*	*19*
Amaresa	6.57	5.74	-	23	0.04	50	35	15
Ambo	7.03	6.64	-	25	1.84	32	35	33
Awash	7.61	7.04	3.7	13	0.58	52	5	43
Metehara	8.44	7.64	4.6	16	1.79	32	21	47

[a] Mean value for duplicate analysis

Table 2. P, NO_3^- and K (mg/ kg) content in the soil samples for conventional soil testing method[a]

Nutrient	Soil sample site									
	Bako	SD(±)	Amaresa	SD(±)	Ambo	SD(±)	Awash	SD(±)	Metehara	SD(±)
P	21.26	0.46	1.5	0.08	39.96	0.05	16.44	1.1	12	0.66
NO_3^-	1.09	0.03	0.99	0.05	1.52	0.21	3.32	0.14	3.36	0.11
K	92.44	0.94	75.12	0.5	247.6	1.43	344.4	1.22	394.6	0.76

[a] Mean ± S.D. values (mg kg-1)

Table 3.Extractable P, NO_3^- and K concentrations in the soils studied after applying the three universal extractants extraction procedures[a]

Site	Extractants used and the amount in (mg/kg)			Nutrient
	0.02 M $SrCl_2.6H_2O$	0.01 M $CaCl_2.2H_2O$	0.01 M $BaCl_2$	
Bako	35.1 ± 0.36	28.4 ± 1.33	30.9 ± 0.14	P
Amaresa	2.48± 0.03	1.89 ± 0.1	2.03 ± 0.05	P
Ambo	62 ± 0.4	50.6 ± 0.45	56.76 ± 0.11	P
Awash	26.13 ± 0.6	18.62 ± 1.25	21.9 ± 1.35	P
Metehara	22 ± 3.15	15.66 ± 1.08	17.8 ± 0.63	P
Bako	3.41 ± 0.27	2.39 ± 0.19	0.44± 0.04	NO_3^-
Amaresa	2.7± 0.4	1.54± 0.05	2.85 ± 0.12	NO_3^-
Ambo	3.52 ± 0.14	2.9 ± 0.53	3.83 ± 0.2	NO_3^-
Awash	11.18 ± 0.1	9.23 ± 0.04	7.58 ± 0.006	NO_3^-
Metehara	12.3± 0.55	9.9 ± 0.56	8.63 ± 0.34	NO_3^-
Bako	67.28 ± 0.92	57.78 ± 2.34	77.08± 2.09	K
Amaresa	55.28± 0.54	35.9± 0.95	56.8 ± 1.93	K
Ambo	187.6 ± 1.47	87.6 ± 0.9	206.7 ± 1.96	K
Awash	267.8 ± 1.43	147.8 ± 3	321.3± 8.17	K
Metehara	327± 1.9 K	221.4 ± 1.85		350.6 ± 2.04

[a] Results are expressed as mean concentration ± standard deviation

Table 4.Analysis of Variance with equal replication of P, NO_3^- and K extracted by 0.02 M $SrCl_2.6H_2O$, 0.01 M $CaCl_2.2H_2O$ and 0.01 M $BaCl_2$

Soil sample site	Nutrient	Computed F	Tabular F (5%)	Cv(%)
Amaresa	P	57**	5.14	3.31
Ambo	P	693.78**	5.14	0.6
Bako	P	55.1**	5.14	2.5
Awash	P	29.75**	5.14	5
Metehara	P	438.6**	5.14	7.9
Amaresa	NO_3^-	25.66**	5.14	10.3
Ambo	NO_3^-	22.8**	5.14	7.4
Bako	NO_3^-	30.85**	5.14	6
Awash	NO_3^-	1461**	5.14	0.87
Metehara	NO_3^-	41.6**	5.14	4.86
Amaresa	K	245**	5.14	2.6
Ambo	K	5492.16**	5.14	0.93
Bako	K	43.04**	5.14	3.68
Awash	K	3697**	5.14	1.03
Metehara	K	4706.4**	5.14	0.57

** significant at $p < 0.05$

Table 5.Results of t- test between conventional and universal extractants for determination of P.

	Extractants					
Soil sample site	0.02 M $SrCl_2.6H_2O$		0.01 M $BaCl_2$		0.01 M $CaCl_2$.6H2O	
	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$
Bako	13.84	1.85	9.64	1.54	7.14	4.55
Amaresa	0.98	0.124	0.53	0.31	0.39	0.41
Ambo	22.04	1.29	16.8	0.41	10.64	1.46
Awash	9.69	3.01	5.46	4.89	2.18	4.63
Metehara	10	9.9	5.8	2.94	3.66	4.05

Key: t= constant, s= pooled standard deviation, N_1 and N_2= no of replications for the methods.X_1 and x_2 = mean value of P for universal extractants and conventional extraction method respectively.

Table 6. Results of t- test between conventional and universal extractants for determination of NO_3^-.

Soil sample site	Extractants 0.02 M $SrCl_2.6H_2O$		0.01 M $BaCl_2$		0.01 M $CaCl_2$.6H2O	
	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$
Bako	2.32	0.88	2.85	0.18	1.3	0.63
Amaresa	1.71	1.29	1.86	0.43	0.55	0.24
Ambo	2	0.81	2.31	0.95	1.38	1.83
Awash	7.86	0.56	4.26	0.52	5.91	0.48
Metehara	8.94	1.8	5.27	1.17	6.54	1.83

Key; t= constant, s= pooled standard deviation, N_1 and N_2= no of replications for the methods

X_1 = mean value of NO_3^- for universal extractants, x_2 = value of NO_3^- for conventional method

Table 1. Results of t- test between conventional and universal extractants for determination of K

Soil sample site	Extractants 0.02 M $SrCl_2.6H_2O$		0.01 M $BaCl_2$		0.01 M $CaCl_2$.6H2O	
	$X_2 - X_1$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$	$X_1 - X_2$	$\pm ts \frac{\sqrt{N1+N2}}{N1N2}$
Bako	25.16	4.21	15.36	8.55	34.66	8.1
Amaresa	19.84	2.33	18.32	6.39	39.22	3.44
Ambo	60	6.6	40.9	7.8	160	5.41
Awash	76.6	6.05	23.1	9.97	196.6	10.4
Metehara	67.6	6.56	44		173.2	6.42
			5.20			

Key: t= constant, s= pooled standard deviation, N_1 and N_2= no of replications for the methods.X_1 and X_2 = mean value of K for universal extractants and conventional extraction method respectively

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