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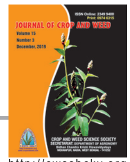

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Evaluation of AB-DTPA for multinutrient extraction from cardamom and pepper plantations in Idukki district of Kerala

*V. I. BEENA, P. GEETHA, P. S. PHILIP, P. SURESHKUMAR, AMRUTHA S. AJAYAN, SAM K. ISSAC, R. S. SOORAJ AND A. K. SHUKLA

Radiotracer Laboratory, College of Agriculture, Vellanikkara, Thrissur, Kerala

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ABSTRACT

For evaluating efficiency of AB-DTPA for multinutrient extraction from cardamom and pepper plantations, geo referenced soil samples were collected from 42 locations at Senapathi and 40 locations at Rajakumari in Idukki district of Kerala which are under cardamom and pepper plantations. Along with the soil samples, index leaves of cardamom and pepper plants from the corresponding locations were analyzed to correlate plant uptake with nutrient availability. Available nutrients in the collected soil samples were extracted with different extractants such as Bray No. 2 for phosphorus, ammonium acetate for K, Ca and Mg, 0.1 N HCl for the estimation of Fe, Mn, Zn and Cu. Available nutrients in these soils were also extracted with AB- DTPA. Correlation analysis revealed a significant positive correlation between available P, K, Zn and Cu extracted with commonly used extractants and that extracted with AB-DTPA in cardamom and pepper plantations. The uptake of P, Ca, Mg and Zn in cardamom was significantly positively correlated with available nutrients extracted with AB-DTPA. Similarly in pepper, the uptake of P, K and Cu was positively correlated with the available nutrients extracted with AB-DTPA. While, uptake of K, Fe, Mn and Cu in cardamom did not show any significant correlation with available nutrients extracted with AB-DTPA. Similarly, uptake of Ca, Mg, Fe, Mn, Zn and B in pepper did not show any significant correlation with available nutrients extracted with AB-DTPA.

Keywords: AB-DTPA, black pepper, cardamom, multinutrient extractant, nutrient availability

Kerala which is located at the southernmost tip of India is renowned as the land of spices. Kerala has a well known position at global spice market in terms of production as well as quality. The climatic condition prevails in Kerala is ideal for the cultivation of wide variety of spices. Black pepper (*Piper nigrum*) and cardamom (*Elettaria cardamomum*) known as king and queen of spices, respectively are grown widely in the Western Ghats belt of Idukki district of Kerala. These crops have great economic value and used as flavoring agents, preservatives and medicines and have a huge demand for export (Sharangi *et al*., 2010).

Soils of Idukki district comprise forest loam, lateritic, brown hydromorphic and alluvial soil and these soils are showing an acidic pH ranging from 4.5 to 5.5 (KSPB, 2013). The crops such as cardamom and pepper are grown mainly in forest loam soils which are rich in organic carbon content. But the excessive use of fertilizers has degraded the soil fertility and productivity. In order to reestablish the soil health and productivity precise application of chemical fertilizers is very essential. Monitoring of soil health and soil test based recommendations of chemical fertilizers is gaining importance in the present scenario. There are standardized analytical procedures for the extraction and analysis of different nutrients present in the soil. The nutrient extraction is a tedious process as extractants used differ based on nutrients. So the analytical procedures can be simplified by the use of a common or universal extractant which can extract all the nutrients simultaneously.

To assess available nutrients in soils, it is economic to use multinutrient extractant like AB-DTPA, especially in soil testing labs dealing with large number of soil samples. It reduces cost of analysis and time. At the same time, the nutrients extracted can be easily estimated using multielement analyzer like ICP (inductively coupled plasma emission spectrometer) or AAS (atomic absorption spectrophotometer).

The AB-DTPA (ammonium bicarbonate - di ethylene tri amine penta acetic acid) is a multinutrient extractant introduced by Soltanpour and Schwab (1977). Soltanpour and Workman (1979) modified chemical composition of AB-DTPA by removing carbon black from its composition in order to reduce the error in the estimation of nutrients. The NH_4^+ ion present in the AB-DTPA replaces exchangeable cations such as Na, K, Ca and Mg. At the same time HCO_3^- ion AB-DTPA, extract available P, S, B and Mo and DTPA extract trace

Email: isotopes@kau.in

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elements and heavy metals like Zn, Fe, Cu, Mn, Pb, Ni, Cd etc. present in the soil. Thus AB- DTPA acts as an efficient multi nutrient extractant for extraction of available nutrients in the soil.

The suitability of AB-DTPA in the extraction and determination of macro and micro nutrients in alkaline soil was already proved by Soltanpour *et al*. (1979). In the present study, AB-DTPA is used as an extractant to evaluate its efficiency as a multinutrient extractant in cardamom and pepper plantations of Idukki districts of Kerala. Kerala soils are generally acidic in nature. Thus the efficiency of AB-DTPA in acidic soil under permanent vegetation of cardamom and pepper is studied. The available nutrients extracted with AB-DTPA were correlated with the available nutrients extracted with commonly used extractants and nutrient uptake by the crop plants such as cardamom and pepper.

MATERIALS AND METHODS

Geo referenced soil samples from cardamom and pepper plantations of Idukki district were collected. Nearly 42 samples were collected from cardamom and pepper plantation at Senapathi and 40 samples from Rajakumari of Idukki districts. Available nutrients in the soil samples were extracted with commonly used extractants like Bray No. 2 for available P, neutral normal ammonium acetate for available K, Ca and Mg, 0.1 M HCl for Fe, Zn, Cu. and Mn and hot water for available boron and these nutrients were determined using multi-element analyzer -inductively coupled plasma emission spectrometer (Jackson, 1973). The same soil samples were extracted with AB-DTPA (1 M ammonium bicarbonate (NH_4HCO_3) and 0.005 M DTPA (adjusted to pH 7.6) and analysed for the available nutrients. AB-DTPA was prepared by dissolving 1.97 g DTPA and 79.06 g ammonium bicarbonate (NH_4HCO_3) in 800 ml distilled water. The pH was adjusted to 7.6 with ammonium hydroxide and dil. HCl and then the solution was made up into 1 litre. For extraction nutrients with AB-DTPA, 20 ml of the extractant was added to 10 g soil and it was shaken for 15 minutes. The P, K, Ca, Mg, Fe, Zn, Mn, Cu and B in the extract were determined using ICP. The data obtained was statistically analyzed to obtain correlation between available nutrients extracted by AB-DTPA and other conventional extractants. Also the correlation between AB-DTPA, available nutrients and plant nutrient uptake were determined.

RESULTS AND DISCUSSION

Cardamom

In the cardamom plantations AB- DTPA extracted P ranged from 10.11 to 21.23 mg kg^{-1}. Soils with AB-DTPA extracted P greater than 8 mg kg^{-1} is considered as sufficient in P for plant growth (Soltanpour, 1985). Thus all the soils collected under cardamom plantations were sufficient in P content. Available P extracted from Bray No. 2 ranged from 22.34 to 54.67 mg kg^{-1} and soils were high in P content. Thus correlation analysis revealed a highly significant positive correlation (0.81**) between available P extracted by Bray No. 2 and AB-DTPA. But the amount of P extracted with AB-DTPA methods was comparatively lower than that extracted by Bray method. It may be due to high Fe and Al content in the acidic soil which fixes soil P in to their phosphates (Lindsay, 1979). More than that H^+ and F^- ions are efficient agent for P extraction than HCO_3^- ions. Similar results were reported by Elrashidi *et al.* (2003) and Sharma *et al*. (2018). It might also be due to the small quantity of AB-DTPA extractant and shorter shaking time taken in the extraction procedure. When more amount of extractant remains with soil for a longer time, more quantity of nutrients is extracted (Khan *et al*., 2006). Similar results were reported by Soltanpour and Schuwab (1977) for neutral and alkaline soils and Madurapperuma and Kumaragamage (1999) for acidic soils.

In the cardamom plantation, AB-DTPA extracted K ranged from 141.34 to 189.56 mg kg^{-1} and that of ammonium acetate (NH_4OAc) extractable K ranged from 298.45 to 325.46 mg kg^{-1}. Similar to P comparatively low extraction of K in AB-DTPA method than ammonium acetate method might be due to the more amount ammonium ions present in NH_4OAc than AB DTPA which effectively replace exchangeable K from all the specific sites (Khan, 2008). Also the amount of extractant and shaking time might have influenced the amount of K extracted (Khan *et al*., 2006). In correlation analysis (Table 1), a significant positive correlation (0.97**) was noticed for available K extracted with AB-DTPA and ammonium acetate. Similar results were reported by Madurapperuma and Kumaragamage (1999) and Malathi and Stalin (2018) for acidic soils. But in the case of Ca and Mg, the collected soil samples were deficient in Ca and Mg. Extraction of soil with NH_4OAc revealed Ca and Mg content of soil was less than 300 and 120 mg kg^{-1}, respectively indicating that the soils were deficient in Ca and Mg. AB-DTPA extracted Ca in the soils ranged from 12-15 mg kg^{-1} and that of Mg ranged from 3.46 to 6.34 mg kg^{-1}. Ca and Mg extracted by both AB-DTPA and ammonium acetate methods has not shown any significant correlation, which might be due to the relatively low Ca and Mg content in the soil. Similar results were reported by Barbarick and Workman (1987) and Madurapperuma and Kumaragamage (1999).

In the case of micronutrients, AB-DTPA extracted Fe in the soil ranged from 10.88 to 15.56 mg kg^{-1}, Mn

Table 1: Correlation between different extractants in cardamom

	Av. PAB-DTPA	Av. KAB-DTPA	Av.CaAB-DTPA	Av.Mg AB-DTPA	Av.Fe AB-DTPA	Av.Mn AB-DTPA	Av.Zn AB-DTPA	Av.Cu AB-DTPA	Av.BAB-DTPA
Av.PBray No. 2	0.81**		-0.53**				0.33*		
Av.K1N Neutral Am.acetate		0.97**	0.59**		-0.33*				
Av.Ca1N Neutral Am.acetate	0.68**		-		-0.56**		0.40*		
Av.Mg1N Neutral Am.acetate	0.73**			-			0.45**		
Av.Fe0.1N HCl	0.38*				-				
Av.Mn0.1N HCl	0.46**					-	0.44**		
Av.Zn0.1N HCl	0.45*			-0.57**	-0.46**	-0.35*	0.99**		
Av.Cu0.1NHCl								0.67**	
Av. BHot water									-

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed)

Table 2: Correlation between different extractants and plant nutrient content in cardamom

	Plant nutrient content								
	Phosphorus	Potassium	Calcium	Magnesium	Iron	Manganese	Zinc	Copper	Boron
Av. P (BrayNo. 2)	0.62**	0.55*	-0.59**	0.44**		-0.55**			-0.46**
Av. P (AB-DTPA)	0.74**	0.78**	-0.75**	0.68**		-0.77**			-0.58**
Av.K (AB-DTPA)	0.33*	-							
Av.K (1N neutral am.acetate)		-							
Av.Ca (AB-DTPA)	0.36*	-0.40*	0.40*			0.36*			0.37*
Av.Ca (1N neutral am.acetate)	0.35*	0.49**	-0.47**	0.48**		-0.58**	0.35*		
Av.Mg (AB-DTPA)				-					
Av.Mg (1N neutral am.acetate)	0.65**	0.65**	-0.75**	0.64**		-0.79**	0.38*		-0.43*
Av.Fe (AB-DTPA)		-0.37*	0.39*	-0.44*	-	0.44**		0.44**	
Av.Fe (0.1N HCl)					-				
Av.Mn (AB-DTPA)						-	-0.47**		
Av.Mn (0.1NHCl)						-			
Av.Zn (AB-DTPA)	0.33*	0.40*		0.33*		-0.36*	0.34*		
Av.Zn (0.1NHCl)	0.35*	0.43**		0.36*		-0.40*	0.38*		
Av.Cu (AB-DTPA)	-0.37*	-0.47**		-0.44*		0.40*	0.49**	-	
Av.Cu (0.1NHCl)	-0.40*	-0.33*		-0.33*		0.36*	0.43**	-	
Av.B (Hotwater)									-

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed)

Table 3: Correlation between different extractants in pepper

	Av. PAB-DTPA	Av.KAB-DTPA	Av.Ca AB-DTPA	Av.Mg AB-DTPA	Av.Fe AB-DTPA	Av.Mn AB-DTPA	Av.Zn AB-DTPA	Av.Cu AB-DTPA	Av.BAB-DTPA
Av.PBray No. 2	0.82**		0.68**					0.48**	
Av.K1N Neutral Am.acetate		0.95**	0.45**						0.37*
Av.Ca1N Neutral Am.acetate	0.53**		-		-0.44**			0.51**	
Av.Mg1N Neutral Am.acetate				-					0.41**
Av.Fe0.1N HCl	0.38*				-				0.31*
Av.Mn0.1N HCl	0.66**				-0.32*	-		0.57**	
Av.Zn0.1N HCl		0.32*					0.90**		
Av.Cu0.1NHCl	0.68**				-0.32*			0.99**	0.33*
Av.BHot water		0.36*		0.32*	0.43**				-

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed)

Table 4: Correlation between different extractants and plant nutrient content in pepper

	Plant nutrient content								
	Phosphorus	Potassium	Calcium	Magnesium	Iron	Manganese	Zinc	Copper	Boron
Av. P (BrayNo. 2)	0.38*			-0.33*	0.43**			0.48**	0.34*
Av. P (AB-DTPA)	0.54**		-0.44**	-0.52**	0.6**			0.72**	0.56**
Av.K (AB-DTPA)		0.46**					0.38*		
Av.K (1N neutral am.acetate)		0.47**				-0.31*			
Av.Ca (AB-DTPA)	0.41**		-	-0.36*			0.37*	0.41**	0.39*
Av.Ca (1N neutral am.acetate)			-	-0.40*	0.38*		0.41**	0.43**	0.37*
Av.Mg (AB-DTPA)	-0.32*			-		-0.38*		-0.33*	
Av.Mg (1N neutral am.acetate)	-0.4*	0.34*		-		-0.35*		-0.40**	0.33*
Av.Fe (AB-DTPA)	-0.47**				-		-0.40**	-0.41*	-0.39*
Av.Fe (0.1N HCl)			-0.49*		-				
Av.Mn (AB-DTPA)				-0.35*		-			
Av.Mn (0.1NHCl)	0.4**			-0.52**	0.49**	-	0.34*	0.53**	0.46**
Av.Zn (AB-DTPA)							-		
Av.Zn (0.1NHCl)							-		
Av.Cu (AB-DTPA)	0.63**			-0.39*	0.63**	0.42**	0.39*	0.71**	0.65**
Av.Cu (0.1NHCl)	0.67**			-0.39*	0.61**	0.44*	0.42*	0.75**	0.71**
Av.B (Hotwater)	-0.56**				-0.36*	-0.35*		-0.36*	-

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed) ranged from 3.45 to 7.68 mg kg^{-1}, Zn content ranged from 3.53 to 6.45 and Cu content ranged from 1.78 to 5.34 mg kg^{-1}. Results obtained were in accordance with that reported by Khan *et al.* (2006) and Mekala *et al.* (2019). In 0.1 N HCl extractions also all the four micronutrients in the soils were found to be in sufficient range as per critical limits of micronutrients in the Kerala soils (KAU, 2016). All the micronutrients extracted with AB-DTPA were slightly less than that extracted with 0.1 HCl. It might be due to the acidic pH of the soil where diluted acid acts as more effective extracting agent than DTPA. But B was not detected in AB-DTPA extract and in hot water extract B content was less than 0.3 mg kg^{-1}. It might be due to the low concentration of B in the soil, it was not extracted with AB-DTPA.

In the correlation analysis a positive correlation was obtained between the zinc (0.99**) and copper (0.67**) extracted by 0.1N HCl with the corresponding nutrient extracted with AB-DTPA (Table 1). There was no significant correlation noticed for Fe and Mn extracted with 0.1N HCl and hot water extracted B with that these nutrients extracted with AB-DTPA. It may be due to the high content of Fe and Mn and low level of B in the soil. Similar results were reported by Madurapperuma and Kumaragamage (1999, 2008).

In the case of plant uptake, phosphorus content in plant had significant positive correlation with available phosphorus (Table 2) extracted by both AB-DTPA (0.74**) and Bray No. 2 (0.62*). However calcium content in plant had significant positive correlation with available calcium extracted by AB-DTPA (0.40*) and negative correlation with neutral normal ammonium acetate extracted calcium (-0.47**). Significant positive correlation of plant magnesium content was obtained with available Mg extracted by neutral normal ammonium acetate (0.64**), but that extracted with AB-DTPA did not show any significant correlation. Zinc content in the plant was significantly positively correlated with available zinc extracted by both AB-DTPA (0.34*) and 0.1 N HCl (0.38*). Nutrients such as K, Fe, Mn, Cu and B in the plant did not show any correlation with the corresponding available nutrients extracted with AB-DTPA as well as conventional extractants.

Pepper

Soils collected from pepper plantation have shown same trend as that of cardamom in macro and micronutrient extraction. The AB-DTPA extracted P ranged from 9.46 to 23.84 mg kg^{-1}, K ranged from 129.34 to 216.56 mg kg^{-1}, Ca ranged from 6.36 - 10.68 mg kg^{-1} and that of Mg ranged from 2.46 to 5.34 mg kg^{-1}. All these four nutrients were extracted in comparatively higher quantity than the conventional extraction method as mentioned by Sharma *et al.* (2018). As per the conventional ratings, the soils were high in P and K content and deficient in Ca and Mg.

In the case of micronutrients, AB-DTPA extracted Fe in the soil ranged from 12.85 to 18.34 mg kg^{-1}, Mn ranged from 5.75 to 9.18 mg kg^{-1}, Zn content ranged from 2.83 to 5.79 and Cu content ranged from 1.34 to 4.44 mg kg^{-1}. In 0.1 N HCl extractions also all the four micronutrients in the soils were found be in sufficient in range as per critical limits of micronutrients in the Kerala soils (KAU, 2016). B content in AB-DTPA extract was 0.06 mg kg^{-1} and in hot water extract B content was 0.41 mg kg^{-1}. Results obtained were in accordance with that reported by Madurapperuma and Kumaragamage (1999), Elrashidi *et al.* (2003), Khan *et al.* (2006), Sharma *et al.* (2018) and Mekala *et al.* (2019).

Similar to cardamom, in the pepper plantation significant positive correlations (Table 3) were obtained between phosphorus (0.82**) extracted by Bray No. 2, potassium (0.95**) zinc (0.90**) and copper (0.99**) extracted by 0.1N HCl and the corresponding nutrients extracted with AB-DTPA. There was no significant correlation between available Ca extracted with neutral normal ammonium acetate and AB-DTPA and Fe and Mn extracted with 0.1 N HCl and AB-DTPA. This might be due to the low Ca and high Fe and Mn content in the soil. Also no significant correlation was obtained between B extracted by AB-DTPA and hot water. It might be due to the low B content in soil. Results obtained were in accordance with that reported by Barbarick and Workman (1987), Madurapperuma and Kumaragamage (1999), Khan *et al.* (2006) and Mekala *et al.* (2019).

In the case of nutrient content in index plant part of pepper, phosphorus content was significantly and positively correlated with both available P extracted by Bray No. 2 (0.38*) and AB-DTPA (0.54**). Potassium content and copper content in plant were found to have significant positive correlation with available content extracted by both extractants. However calcium, magnesium, iron, manganese, zinc, and boron contents in plant were not found to have any significant correlation with available status in soil (Table 4). This might be due to the low content of Ca, Mg and B and high content of Fe, Mn and Zn in the soil.

The available nutrients under cardamom and pepper plantations of Idukki district of Kerala can be extracted and indexed with AB-DTPA extraction. In the study AB-DTPA was found to be efficient and effective as that of conventional extractants and can be substituted in the routine soil analysis. It conserves time and reduces analytical cost on soil analysis. In the study conducted in the soils of cardamom and pepper plantation, highly significant correlation was obtained between nutrients extracted with AB-DTPA and that of conventional extractants. But in the case of few nutrients like Ca, Mg, Fe, Mn and B the correlation between the extractants was affected due to their very low and high content in the soil. Even though, AB-DTPA can be used as a substitute for conventional extractants in determination of multiple nutrients and nutrient indexing with a different range limit of rating. In the case of nutrient uptake by crop plants more correlation was obtained with AB-DTPA extraction than other conventional extractants

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REFERENCES

Barbarick, K. A. and Workman, S.M. 1987. Ammonium bicarbonate- DTPA and DTPA extractions of sludge-amended soils. *J. Environ. Qual.,* **16**: 125-130.

Elrashidi, M.A., Mays, M.D. and Lee, C.W. 2003. Assessment of Mehlich-3 and ammonium bicarbonate-DTPA extraction for simultaneous measurement of fifteen elements in soils. *Commun. Soil Sci. Plant Anal*., **34**: 2817-2838.

Jackson, M.L. 1973. Soil Chemical Analysis. Englewood Cliffs, New Jersey, USA: Prentice Hall. Inc.

KAU [Kerala Agricultural University]. 2016. *Package of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 393p.

Khan, M.Z. 2008. Test of AB-DTPA as a routine measure of soil extractable phosphorus and potassium for crop fertilization. Ph. D (Ag) Thesis, Agricultural University, Pakistan. 304p.

Khan, M. Z., Yousaf, M., Akthar, M. E. and Ahmad, S. 2006. Comparison of AB-DTPA method for extractable P and K from prominent soils of Potohar region, *Pakistan. J. Chem. Soc. Pak.,* **29**: 26-32.

KSPB [Kerala State Planning Board]. 2013. *Soil Fertility Assessment and Information Management for enhancing Crop Productivity in Kerala*. Kerala State Planning Board, Thiruvananthapuram. pp. 1-514.

Lindsay, W.L. 1979. Chemical Equilibrium in Soils. New work: John Wiley and sons. 162p.

Madurapperuma, W. S. and Kumaragamage, D. 1999. Evaluation of AB-DTPA extractant for the estimation of plant available macro and micronutrients in acidic and neutral soils. *J. Soil Sci. Soc. Sri Lanka,* **11**: 28-36.

Madurapperuma, W. S. and Kumaragamage, D. 2008. Evaluation of ammonium bicarbonate – DTPA (ABDTPA) as a multi-nutrient extractant for acidic lowland rice soils. *Commun. Soil Sci. Plant Anal*., **39**: 1773-1790

Malathi, P. and Stalin, P. 2018. Evaluation of AB -DTPA extractant for multinutrients extraction in soils. *Int. J. Curr. Microbiol. App. Sci.,* **7:** 1192-1205.

Mekala, S., Mantri, C.P., Purma, S., Pasupuleti, S.B. and Kumar, A. 2019. Evaluation and Comparison of DTPA extracting methods for available cationic micronutrients in non-acidic soils of Andhra Pradesh, India. *J. Agric. Sci. Technol.,* **9:** 269-277.

Sharangi, A. B., Kumar, V. and Sahu, P. K. 2010. Survivability of black pepper (*Piper nigrum* L.) cuttings from different portions of vine and growing media. *J. Crop Weed,* **6**: 52-54.

Sharma, S. K., Sharma, A., Rana, S. and Kumar, N. 2018. Evaluation of multi-nutrient extractants for determination of available P, K, and micronutrient cations in soil. *J. Plant Nutr.,* **41**: 782-792.

Soltanpour, P. N. 1985. Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. *Commun. Soil Sci. Plant Anal*., **16**: 323-338.

Soltanpour, P.N. and Workman, S.M. 1979. Modification of the NH_4HCO_3 – DTPA soil test to omit carbon black. *Commun. Soil Sci. Plant Anal.,* **10:** 1411-1420.

Soltanpour, P. N. and 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.