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염류집적 비닐하우스 토양의 교환성 양이온 측정

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Measurement of Exchangeable Cations in Salt Accumulated Vinyl Greenhouse Soils

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Abstract

BACKGROUND: Although 1 M NH₄OAc (pH 7.0) is predominantly used as the extractant of exchangeable cations in agricultural soils, this method is unsuitable for extracting the cations in saline and calcareous soils. This study was performed to select a proper method to determine exchangeable cations in vinyl greenhouse soils.

METHODS AND RESULTS: Exchangeable cations (Ca, Mg, K, Na) in saline vinyl greenhouse soils were determined after extraction with 1 M NH₄OAc (pH 7.0 and 8.5) and 1 M alcoholic NH₄Cl (pH 8.5). Sum of exchangeable cations of the soils extracted with 1 M NH₄OAc at pH 7.0 was 1.9-2.5 times greater than soil cation exchange capacity determined at pH 7.0, even though soluble salts were pre-removed. A similar result was found when the cations were extracted with 1 M NH₄OAc at pH 8.5. Those results are mostly due to the overestimation of exchangeable Ca and Mg, linked to a partial dissolution of sparingly soluble salts in NH₄OAc solution. When extracted with 1 M alcoholic NH₄Cl at pH 8.5, extractable Ca and Mg decreased significantly due to the lower solubility of Ca and Mg carbonates in the extractant. And the sum of exchangeable cations was very close to the

corresponding exchange capacity of soils.

CONCLUSION: Alcoholic NH₄Cl (pH 8.5) is proposed as a reliable extractant in determination of exchangeable cations in saline vinyl greenhouse soils. And soluble salts should be removed prior to the extraction of exchangeable cations.

Key words: Alcoholic NH₄Cl, Cation exchange capacity, Exchangeable cation, Saline soil, Vinyl greenhouse

서론

(CEC) , , , pH , Ca²⁺, Mg²⁺, K⁺, Na⁺ , H⁺ Al³⁺ , pH 가 CEC pH 7.0 1 M NH₄OAc pH

(Sumner and Miller, 1996).

CEC pH가 7.0 CEC

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CEC, CEC, pH, potential CEC, CEC(effective), CEC, Ca²⁺, Mg²⁺, pH, 1 M NH₄OAc, CaCO₃, MgCO₃, CaSO₄, Ca²⁺, Mg²⁺, CEC (Bascomb, 1964; Begheyn, 1987; Misopolinos and Kalovoulos, 1984; Polemio and Rhoades, 1977; Ravina and Gurovich, 1977; Tucker, 1985).

(Misopolinos and Kalovoulos, 1984; Polemio and Rhoades, 1977; Wang *et al.*, 2005).

CaCO₃, (Wada and Furumura, 1994), pH 7.0, 1 M NH₄OAc, (Amrhein and Suarez, 1990; Normadin *et al.*, 1998; Thomas, 1982).

pH 7.0, 1 M NH₄OAc, CEC, (Menzies and Bell, 1988).

CaCO₃, pH 7.0, 1 M NH₄OAc, Ca, Mg (Chung, 2005; Kim *et al.*, 2016a, 2016b; Lee and Kim, 2006; Yang *et al.*, 2006).

CEC, 가, CEC, 가, Ca, Mg, Ca, Mg, alcoholic NH₄Cl, choline chloride, pH 8.5, NH₄OAc, (Normadin *et al.*, 1998; So *et al.*, 2006; Tucker, 1985).

가, 1 M NH₄OAc (pH 8.5), 1 M alcoholic NH₄Cl (pH 8.5), CEC, 가.

재료 및 방법

토양 시료 및 이화학성 분석

3, 10 cm, 2 mm, pH 1:5 / 1, pH meter (Mettler Toledo Delta 340, Halstead, England) (electrical conductivity, EC) 10 g, 100 mL, 50 mL, 가, 200 rpm, 1, Whatman No. 42 (Corning Check Mate 90, Corning, New York, USA) Walkley-Black (Nelson and Sommers, 1982). CEC, pH 7.0, 1 M NH₄OAc, 95% ethanol, 1 M KCl, NH₄⁺, Kjeldahl (Chapman, 1965). 1 M HCl, 가, 24, HCl, 0.5 M NaOH, CaCO₃ (Elfaki *et al.*, 2016).

토양의 교환성 양이온 측정

pH 7.0, 8.5, 1 M

Table 1. Physicochemical properties of soil samples used for the experiment

Soil	pH (1:5 H ₂ O)	EC ^{a)} (1:5 H ₂ O)	Carbonate	Organic matter	CEC ^{b)}	
		dS/m	CaCO ₃ %	g/kg	cmol _c /kg	
Open field	1	6.2	0.42	0.3	23.6	14.2±0.9
	2	6.0	0.24	0.3	25.5	14.1±1.0
	3	6.3	0.10	0.4	28.2	15.8±0.7
Vinyl house	1	7.9	1.20	3.3	33.6	16.0±0.4
	2	8.3	2.22	5.8	34.7	16.1±0.7
	3	8.2	2.83	5.5	43.7	15.6±0.8

^{a)} EC, electrical conductivity.

^{b)} CEC, cation-exchange capacity. Data are mean±standard deviation.

NH₄OAc pH 8.5 1 M alcoholic NH₄Cl
(Normandin *et al.*, 1998; Thomas, 1982; Tucker, 1985). 1 M NH₄OAc 99.5% glacial acetic acid 57 mL 800 mL

Germany)

(H⁺ Al³⁺) 1 M
0.1 N NaOH

68 mL NH₄OH 가
NH₄OH pH 7.0 8.5
가 1 L

결과 및 고찰

Alcoholic 1 M NH₄Cl 54 g NH₄Cl 310 mL
665 mL 95% ethanol 가

3

3

Table 1

NH₄OH pH 8.5
가 1 L
가

pH 6

pH 8.0
pH가

3

가 So (2006)

3 g 50 mL centrifuge tube
60% ethanol 20 mL 가 150 rpm 30
, 3000 rpm

EC

1:5

EC

(EC_c)

4

20% glycerol 20
mL 1 가

dS/m (Jung *et al.*, 2001; United States Salinity Laboratory Staff, 1954).

20 mL 가 250 rpm
, 3000 rpm

CaMg(CO₃)₂

CaCO₃,

100 mL

15 mL

4

100 mL

가
tube 3 g 50 mL centrifuge
가

25.8 37.3 g/kg

Ca, Mg, K, Na NH₄OAc

가

(ICP-AES,

Ca Mg

720-ES Series, Varian Inc., Palo Alto, California, USA)

, alcoholic NH₄Cl

(contrAA-300, Analytik Jena, Jena,

가

Table 2. Exchangeable cations in open field and vinyl greenhouse soils extracted with 1 M aqueous NH₄OAc solution adjusted to pH 7.0

Soil	Pre-removal of soluble salts	Exchangeable cations					Sum ^{a)}
		Ca	Mg	K	Na	cmol _c /kg	
Open field	1	No	8.90	1.43	0.49	0.34	11.2±0.8
		Yes	8.40	1.39	0.46	0.31	10.6±0.5
	2	No	9.90	2.03	0.66	0.30	12.9±1.2
		Yes	8.60	1.67	0.56	0.28	11.1±0.7
	3	No	9.50	2.54	0.76	0.34	13.1±1.3
		Yes	9.00	2.39	0.70	0.28	12.4±1.0
Vinyl house	1	No	25.2	6.57	0.76	0.96	33.5±3.2
		Yes	22.1	6.34	0.69	0.57	29.7±2.5
	2	No	28.3	11.7	1.75	1.37	43.1±4.1
		Yes	27.1	10.3	1.51	0.54	39.5±2.7
	3	No	25.1	13.6	2.66	1.14	42.5±3.9
		Yes	24.9	10.8	2.33	0.46	38.5±3.4

^{a)} Data are mean±standard deviation.

pH 7.0 1 M NH₄OAc

Table 2 . pH가 6 EC

pH 7.0 CEC Ca, Mg, K, Na

가

가 CEC가 15 cmol_c/kg pH 7.0 1 M NH₄OAc Ca

가 CEC 5-15% Mg 12-23 5-13 cmol_c/kg K

1.2-3.4 cmol_c/kg 4-8 cmol_c/kg (Chung, 2005; Yang *et al.*, 2006; Kim *et al.*, 2016a, 2016b).

H⁺ Al³⁺ 1, 2, 3 0.11, 0.12, 0.15 pH

cmol_c/kg , CEC 1% 7.0 1:5 H₂O EC가 5 dS/m

가 CEC

가 alcohol 가 Ca Mg

가

CEC가 가

NH₄OAc CEC pH 7.0 1 M (Gillman, 4 dS/m (EC_e)가

1981; Laurier and Jan, 1982). 가 가

(Lee *et al.*, 2012), EC_e가 4 dS/m

가

가 (So *et al.*, 2006). EC_e가 2 dS/m 가

Ca, Mg, K, Na CEC 1.9-2.7 가 (Polemio and Rhoades, 1977),

가 EC_e가 2 dS/m 가

, CEC 14-23 cmol_c/kg

Ca Mg 60% ethanol 가

20% glycerol

Ca Mg pH 8.5 1 M NH₄OAc

Table 3. Exchangeable cations in vinyl greenhouse soils extracted with 1 M aqueous NH₄OAc solution adjusted to pH 8.5

Soil	Pre-removal of soluble salts	Exchangeable cations					
		Ca	Mg	K	Na	Sum ^{a)}	
----- cmol _c /kg -----							
Vinyl house	1	No	15.5	7.27	0.98	1.15	24.9±1.3
		Yes	12.8	5.40	0.62	0.72	19.5±1.7
	2	No	18.6	10.1	2.08	1.59	32.3±0.8
		Yes	14.9	7.67	1.37	0.88	24.8±1.1
	3	No	19.6	11.2	2.51	1.27	34.6±1.3
		Yes	16.5	8.21	1.98	0.64	27.3±1.1

^{a)}Data are mean±standard deviation.

Table 4. Exchangeable cations in vinyl greenhouse soils extracted with 1 M alcoholic NH₄Cl solution adjusted to pH 8.5

Soil	Pre-removal of soluble salts	Exchangeable cations					
		Ca	Mg	K	Na	Sum ^{a)}	
----- cmol _c /kg -----							
Vinyl house	1	No	7.34	6.62	1.94	1.81	17.7±0.9
		Yes	6.89	5.62	1.50	1.26	15.3±1.2
	2	No	7.25	8.49	2.41	2.26	20.4±1.0
		Yes	6.65	6.53	2.03	1.28	16.5±0.6
	3	No	7.35	9.07	3.19	2.20	21.8±1.7
		Yes	6.38	6.03	2.56	1.35	16.3±1.1

^{a)}Data are mean±standard deviation.

가 Table 3 . 5 mmol/L (Wada and Furumura, 1994).
 Ca, Mg, K, Na , 1 M NH₄OAc
 CEC 가 pH 8.5 CaCO₃
 CEC 1.2-1.8 . pH 7.0 1
 M NH₄OAc (Table 2), Ca
 1 M NH₄OAc pH 8.5 Mg water/alcohol
 Ca Mg pH 7.0 1 M NH₄OAc 가
 Normadin (1998) pH 4.5 10.0 alcoholic NH₄Cl CaCO₃ pH 8.5 1 M
 (CaCO₃) 3.5% Ca , Wada and Furumura, 1994), pH 8.2 80% methanol
 pH가 8.5 Ca , MgCO₃ 0.02 mmol/L
 pH 8.5-10.0 Ca K, (Misopolinos and Kalovoulos, 1984).
 Mg, Na CaCO₃ pH 8.2-8.5 50-80% ethanol methanol
 pH 8.5 1 M NH₄OAc CaCO₃ (Begheyn, 1987; Misopolinos
 and Kalovoulos, 1984; Polemio and Rhoades, 1977;
 , pH 8.5 1 M NH₄OAc CaCO₃ Tucker, 1985; Wang *et al.*, 2005). 1 M
 . pH 8.5 1 M NH₄OAc CaCO₃ NH₄OAc

1 M alcoholic NH₄Cl Tucker (1985) pH 7.0 CEC
 pH 8.5 alcoholic NH₄Cl Ca Mg
 가
 Table 4
 가 pH 8.5 1 M
 alcoholic NH₄Cl NH₄OAc
 Ca Mg pH 7.0 8.5 1 M NH₄OAc
 (Table 2, 3).
 60% ethanol 20% glycerol
 가
 2.4-5.5 cmol_c/kg 가
 pH 8.5 1 M alcoholic NH₄Cl
 pH 7.0 1 M
 NH₄OAc CEC
 가
 가
 pH가 7.0 H
 Al 가
 pH 7.0 CEC pH 8.5
 가 pH 8.5 1 M alcoholic
 NH₄Cl pH 7.0
 CEC
 CEC
 가 pH 8.5 1 M alcoholic
 NH₄Cl
 , alcohol
 가
 가
 (Gupta *et al.*, 1985; Polemio and Rhoades, 1977).

요 약

가 가
 가 pH 7.0 1
 M NH₄OAc Ca Mg
 가
 1 M NH₄OAc
 (pH 7.0)
 pH 7.0 CEC
 가
 CEC 1.9-2.5 가
 pH 8.5 1 M alcoholic NH₄Cl

pH 7.0 CEC
 pH 8.5 alcoholic NH₄Cl Ca Mg
 가
 NH₄OAc
 alcoholic NH₄Cl

Note

The authors declare no conflict of interest.

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