Spectrophotometric Determination of Soil Chemical Properties Using Soiltek® KA-P Spectrophotometer

Hae-Nam Hyun*, Sang-Sil Oh**, Bon-Jun Koo*** and Ho-Jun Kang****

ABSTRACT

To enable rapid and convenient soil test, new soil analytical methods, which require only one instrument, UV/Vis spectrophotometer, were developed and named "Soiltek KA-P spectrophotometric methods". The Soiltek® KA-P spectrophotometric method was compared with standard method of RDA in analytical capability for soil chemical properties. Using the 78 soils collected from upland, paddy, orchard, and vinyl house soils, soil organic matter, exchangeable K, Ca, and Mg, CEC, available SiO₂, and nitrate were analyzed by the two methods. The color stability/(ratio of the absorbance at elapsed time t to the absorbance at time t=0) of organic matter, Ca, Mg, and available SiO₂ decreased to about 2% within one hour. However, that of exchangeable K, CEC, and nitrate remained constant. The results obtained with Soiltek® KA-P spectrophotometric method showed highly significant correlation with those measured by the standard method of RDA(R²=0.9501), in which the slopes were near unity of 1.0±0.05. The standard deviation values of organic matter, exchangeable K, Ca, and Mg, CEC, available SiO₂, and nitrate were apparently lower than ±1.8 g kg⁻¹, ±0.05 cmol+ kg⁻¹, ±0.18 cmol+ kg⁻¹, and ±0.13 cmol+ kg⁻¹, ±1.0 cmol+ kg⁻¹, ±5.0 mg kg⁻¹, and ±10.0 mg kg⁻¹, respectively. All the measurements showed coefficients of variation of less than 7~17% and were within the confidence level of 95%, which means both the methods are precise. Considering the relative simplicity, low cost, precision and accuracy, the proposed Soiltek® KA-P spectrophotometric methods could be recommended as an alternative to standard method.

Key words: Soil analysis, Soiltek KA-P spectrophotometric method, Standard method of RDA, Soil components.

Introduction

A rapid soil test is prerequisite for the fast fertilizer recommendation. However, standard methods for soil test used in Korea are time-consuming, and require several equipments, such as spectrophotometer for nitrate, available phosphate and silicate, atomic absorption spectrophotometer for exchangeable K, Ca, and Mg, titration apparatus for soil organic matter, and Kjeldahl distillation apparatus for CEC. Moreover, for the CEC analysis, complex procedures such as saturating, washing, and extracting steps are required.

Therefore, it is necessary to develop new analytical methods having simple procedure and using only one instrument for fast and convenient soil test without damaging accuracy compared with RDA methods. Soiltek®
KA-P spectrophotometer which is one-touch operation type of soil analyzer was developed to determine soil components for fertilizer recommendation (Hyun et al., 1999). Spectrophotometric methods are more often used because of their simplicity and low cost.

Spectrophotometric techniques were applied to measure soil organic matter contents (Sims and Haby, 1971; De Bolt, 1974), K in leaf (Tubino and Torres, 1992) and fertilizer (Jain and Sarkar, 1976), Ca in paper machine white water (Nyman and Ivaska, 1995), water, urine, pharmaceutical samples (van Staden and Taljaard, 1996), serum, and wastewater (Hansen et al., 1978; Rocha et al., 1998), and Mg in water (Mann and Yoe, 1956; Mann and Yoe, 1957) and soil extract (Peaslee, 1966).

Based on the above methods or principles, in this study more convenient and rapid methods using Solitek® KA-P spectrophotometer were designed for the analysis of organic matter, exchangeable K, Ca, and Mg; cation exchange capacity, available SiO₂; and nitrate in soils. Results from new methods were statistically compared with those from conventional standard methods of RDA.

**Materials and Methods**

1. Soil samples
   The 78 surface soil samples were collected from upland, paddy, orchard, and vinyl house soils to cover various land-uses. The soil samples were air-dried and crushed to pass 2 mm sieves. Among them, 56 soils were used for analyzing organic matter, exchangeable K, Ca, and Mg, and CEC; 32 paddy soils for available SiO₂; and 28 soils from upland and vinyl house for nitrate.

2. Methods
   - **Soil organic matter**
     Walkley-Black method was used for organic matter as a standard method, while Solitek® KA-P spectrophotometric method was modified by changing concentration and reducing reagents for simple preparation from the methods proposed by Sims and Haby (1971) and De Bolt (1974).

   - **Nitrate**
     After extracting from soils with 2M KCl solution, nitrate was determined by Brudne method as a standard method. It was compared with Solitek® KA-P spectrophotometric method which was made from the modification of UV spectrophotometric screening method (APHA, 1998).

   - **Exchangeable K, Ca, and Mg**
     Exchangeable Ca and Mg in solution extracted with 1M ammonium acetate and exchangeable K with sodium acetate buffer solution were analyzed by atomic absorption spectrophotometer (Varian Spectra AA 220). In Solitek® KA-P spectrophotometric method using an aliquot of the extracted solution, exchangeable Ca was determined after modifying the method proposed by Nyman and Ivaska (1995), van Staden and Taljaard (1996), Hansen et al. (1978), Rocha et al. (1998), and Oguma et al. (1985). Using another aliquot of the same extracted solution, exchangeable Mg was determined after modifying the method proposed by Mann and Yoe (1956), Mann and Yoe (1957), and Peaslee (1966). Exchangeable K was determined by modifying the method proposed by Cox et al. (1999), Torres and Tubino (1994), Tubino and Torres (1992). The modification was mainly performed by changing the concentration and the way of mixing or adding reagents for Ca and K.

   - **Available SiO₂**
     After being extracted from soils with 1M sodium acetate solution, available SiO₂ in the solution was determined by the RDA standard method (RDA, 1988). Solitek® KA-P spectrophotometric method modified from the RDA standard method was used for the determination of available SiO₂ contained in the same solution.