



Ultrafast agricultural soil analysis using the Thermo Scientific iCAP 7600 ICP-OES Radial

Authors

James Hannan,
Application Specialist,
Thermo Fisher Scientific,
Hemel Hempstead, UK

Keywords

Agricultural, High speed,
Screening, Soil

Goal

This application note describes agricultural soil screening using the Thermo Scientific iCAP 7600 ICP-OES Radial, resulting in significantly increased productivity.

Introduction

Intensifying economic and environmental pressures have driven farming to adopt new highly technical processes to accelerate growth and enhance yields. One of the techniques used by farmers is targeted fertilization; which ensures that the ideal amount and type of nutrients are distributed while producing minimal waste. This process requires fields to be sampled and then the sample coordinates tagged via GPS (Global Positioning System). These samples are analyzed for nutritional information and the results loaded into a spreader control computer, which directs the fertilizer distribution system to deliver the correct soil nutrient formula to the exact location, promoting ideal growing conditions.

The commercial and private sites performing this type of work are prime examples of cost-effective and rapid turnaround time analyses laboratories. They serve the farming community by analyzing surface soil samples for major, trace and micro-nutrient elements which in turn help to determine the correct type and amount of fertilizer needed for specific patches of arable land. Due to the inherent uncertainty of surface sampling, highly accurate, low-level analysis is not the priority whereas obtaining the soil composition in a short time is. Large numbers of individual samples are analyzed for trends rather than absolute concentrations and the analysis time desired is less than 20 seconds per sample.

Instrumentation

The Thermo Scientific™ iCAP™ 7600 ICP-OES Radial was used for this analysis. The dedicated radial view provides high matrix tolerance while the instrument model offers the Sprint Valve, a high speed, switching valve sample introduction system, which can be used to improve speed of analysis. In conjunction with this instrument, a Teledyne CETAC ASX-560 Autosampler was used in order to provide automatic analysis, freeing the operator to perform other tasks. A large capacity autosampler, such as the Teledyne CETAC XLR-860 Extended rack autosampler, can be used to further increase the number of samples that can be analyzed unattended.

Method development and analysis

Soil samples were extracted with ammonium acetate (commonly known as Mehlich 3) using the following procedure. A solution of 1 M ammonium acetate was made up by dissolving 77 g of ammonium acetate salt (Fisher Scientific, Loughborough, UK) in 1 L of deionized water.

The soil samples were dried, any stones and foreign matter removed and then ground. To 5 g of sample 20 mL of the Mehlich 3 solution was added. These samples were then shaken vigorously for at least 5 minutes and left to react overnight. The samples were then shaken again and filtered before being made up to 250 mL with deionized water. These sample extracts were analyzed directly.

A LabBook was setup using the Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software, to analyze 11 elements commonly required. The elements and the final wavelengths selected can be seen in Table 2. The measure modes and acquisition parameters from the analysis are listed in Table 1. The analysis was performed using the Sprint acquisition mode which further enhances the speed of the instrument.

Table 1. Instrument parameters.

Parameter	Setting	
Pump Tubing (Mini Pump)	Sample Tygon® white/white Drain Tygon® yellow/blue	
Pump Speed	125 rpm	
Nebulizer	V-groove	
Nebulizer Gas Flow	0.65 Lmin ⁻¹	
Spray Chamber	Glass cyclonic	
Auxiliary Gas Flow	0.5 Lmin ⁻¹	
Coolant Gas Flow	12 Lmin ⁻¹	
Center Tube	2 mm	
RF Power	1150 W	
Repeats	1	
Sample Flush Time	1 sec	
Sprint Valve Loop Size	1 ml	
Exposure Time	UV	Vis
	1 sec	1 sec

Results

A locally sourced soil sample was extracted 5 times, using the method described above, each extract was analyzed 10 times, in order to determine analysis precision. The total time required for these 50 repeats was 11 minutes and 35 seconds, which equates to an analysis time of 13.9 seconds per sample. The results of the ten repeats for one of the sample extracts can be seen in Table 2. The relative standard deviations (RSD) of each element over all 50 samples was <10%.

Table 3. Analysis results in mg·kg⁻¹

Element		B	Ca	Cu	Fe	K	Mg	Mn	Na	P	S	Zn
Wavelength (nm)		208.959	183.801	224.700	240.488	769.896	202.582	293.930	818.326	213.618	182.624	206.200
Repeat	Time											
1	17:14:42	3.51	1887	0.85	2.59	4.87	51.2	1.38	29.6	9.57	70	0.71
2	17:14:56	3.33	1917	0.79	2.38	4.46	50.7	1.51	29.3	9.3	73.6	0.76
3	17:15:10	3.66	1943	0.88	2.28	4.91	50.1	1.55	28.5	9.78	68.6	0.73
4	17:15:24	3.52	1880	0.75	2.59	4.87	53.7	1.39	32.6	9.03	71.4	0.7
5	17:15:38	3.18	1742	0.75	2.61	4.23	51.8	1.4	32.6	9.58	68.3	0.72
6	17:15:52	3.25	1945	0.86	2.62	4.24	54.2	1.54	27.6	9.67	70	0.71
7	17:16:06	3.43	1909	0.8	2.5	4.2	49.9	1.38	29.8	9.68	74.7	0.72
8	17:16:19	3.64	1983	0.76	2.43	4.18	52.8	1.46	32.5	9.12	68.4	0.75
9	17:16:33	3.33	1747	0.79	2.31	4.13	52.6	1.76	30.7	9.46	73.3	0.75
10	17:16:47	3.63	1843	0.78	2.52	4.59	47.6	1.51	28.6	9.49	73.6	0.69
Mean		3.45	1880	0.8	2.48	4.47	51.5	1.49	30.2	9.47	71.2	0.72
RSD (%)		5	4.3	5.8	5.1	7.1	3.8	7.8	6.1	2.6	3.5	3.1

Conclusion

The Thermo Scientific iCAP 7600 ICP-OES Radial performed the soil screening analysis to both speed and precision. Its high sensitivity optical design allows for very short exposure times to be used, while retaining the capability for producing ‘quality’ results. The Sprint acquisition mode and the integrated Sprint Valve of the instrument enables ultrafast analyses to be performed with analysis times well under 20 seconds per sample reducing consequently the cost of analysis.

Find out more at thermofisher.com/ICP-OES

For Research Use Only. Not for use in diagnostic procedures. ©2017 Thermo Fisher Scientific Inc. All rights reserved. Tygon is a trademark of Saint-Gobain Corporation. CETAC is a trademark of Teledyne CETAC Technologies Inc. All other trademarks are the property of Thermo Fisher Scientific and its subsidiaries. This information is presented as an example of the capabilities of Thermo Fisher Scientific products. It is not intended to encourage use of these products in any manner that might infringe the intellectual property rights of others. Specifications, terms and pricing are subject to change. Not all products are available in all countries. Please consult your local sales representative for details. **AN43156-EN 0817**

ThermoFisher
SCIENTIFIC