

Ultra-Fast Agricultural Soil Analysis using the Thermo Scientific iCAP 7600 ICP-OES

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Key Words

Agricultural, soil, screening, high speed

Goal

This application note describes agricultural soil screening using the Thermo Scientific™ iCAP™ 7600 ICP-OES, 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 Global Positioning Satellites (GPS). These samples are analysed for nutritional information and the results uploaded to the GPS system, 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 viewing provides high matrix tolerance while the instrument model offers a high speed, switching valve sample introduction system, which can be used to improve speed of analysis. In conjunction with this instrument, a CETAC ASX-520 autosampler was used in order to provide automatic analysis, freeing the operator to perform other tasks. A large capacity autosampler, such as the CETAC XLR-8 extended rack autosampler, can be used to further increase the number of samples that can be analysed unattended.



Figure 2. The Thermo Scientific iCAP 7000 ICP-OES

Table 1. Sample introduction details

Nebulizer		V-Groove
Spray Chamber		Glass Cyclonic
Centre torch		2.0 mm ID
Pump Tubing	Sample	1.016 mm
	Waste	1.524 mm

Method

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 de-ionized 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 de-ionized water. These sample extracts were analysed directly.

A LabBook was setup using the Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS), to analyse 11 elements commonly required. The elements and the final wavelengths selected can be seen in table 3. The measure modes and acquisition parameters from the analysis are listed in table 2. The analysis was performed using the Sprint acquisition mode which further enhances the speed of the instrument.

Table 2. Measure modes and acquisition parameters

Analysis Mode		Sprint
Exposure Time	Low	1 sec
	High	1 sec
# Repeats		1
Sample Flush Time		1 sec
Sample Loop Size		1 ml
Pump Rate		125 rpm
Sample Uptake Time		0.5 sec
RF Power		1150 W
Coolant Gas Flow		12 l/min
Auxiliary Gas Flow		0.50 l/min
Nebulizer Gas Flow		0.65 l/min



Results

A locally sourced soil sample was extracted 5 times, using the method described above, each extract was analysed 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 3. The relative standard deviations (RSD) of each element over all 50 samples was <10%.

Table 3. Analysis results in mg/kg

Element		B	Ca	Cu	Fe	K	Mg
Wavelength (nm)		208.959	183.801	224.700	240.488	769.896	202.582
Repeat 1	26/11/2012 17:14:42	3.51	1887	0.85	2.59	4.87	51.2
Repeat 2	26/11/2012 17:14:56	3.33	1917	0.79	2.38	4.46	50.7
Repeat 3	26/11/2012 17:15:10	3.66	1943	0.88	2.28	4.91	50.1
Repeat 4	26/11/2012 17:15:24	3.52	1880	0.75	2.59	4.87	53.7
Repeat 5	26/11/2012 17:15:38	3.18	1742	0.75	2.61	4.23	51.8
Repeat 6	26/11/2012 17:15:52	3.25	1945	0.86	2.62	4.24	54.2
Repeat 7	26/11/2012 17:16:06	3.43	1909	0.80	2.50	4.20	49.9
Repeat 8	26/11/2012 17:16:19	3.64	1983	0.76	2.43	4.18	52.8
Repeat 9	26/11/2012 17:16:33	3.33	1747	0.79	2.31	4.13	52.6
Repeat 10	26/11/2012 17:16:47	3.63	1843	0.78	2.52	4.59	47.6
Mean		3.45	1880	0.80	2.48	4.47	51.5
Percent RSD		5.0	4.3	5.8	5.1	7.1	3.8

Element		Mn	Na	P	S	Zn
Wavelength (nm)		293.930	818.326	213.618	182.624	206.200
Repeat 1	26/11/2012 17:14:42	1.38	29.6	9.57	70.0	0.71
Repeat 2	26/11/2012 17:14:56	1.51	29.3	9.30	73.6	0.76
Repeat 3	26/11/2012 17:15:10	1.55	28.5	9.78	68.6	0.73
Repeat 4	26/11/2012 17:15:24	1.39	32.6	9.03	71.4	0.70
Repeat 5	26/11/2012 17:15:38	1.40	32.6	9.58	68.3	0.72
Repeat 6	26/11/2012 17:15:52	1.54	27.6	9.67	70.0	0.71
Repeat 7	26/11/2012 17:16:06	1.38	29.8	9.68	74.7	0.72
Repeat 8	26/11/2012 17:16:19	1.46	32.5	9.12	68.4	0.75
Repeat 9	26/11/2012 17:16:33	1.76	30.7	9.46	73.3	0.75
Repeat 10	26/11/2012 17:16:47	1.51	28.6	9.49	73.6	0.69
Mean		1.49	30.2	9.47	71.2	0.72
Percent RSD		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 switching valve sample introduction system of the instrument enables ultra-fast analyses to be performed with analysis times well under 20 seconds per sample reducing consequently the cost of analysis.



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AN43156_E 02/13C

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