

# Accepted Manuscript

Title: Challenging applications for multi-element analysis by laser-induced breakdown spectroscopy in agriculture: A review

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PII: S0165-9936(15)30127-8

DOI: <http://dx.doi.org/doi: 10.1016/j.trac.2016.08.015>

Reference: TRAC 14834

To appear in: *Trends in Analytical Chemistry*



Please cite this article as: Jiyu Peng, Fei Liu, Fei Zhou, Kunlin Song, Chu Zhang, Lanhan Ye, Yong He, Challenging applications for multi-element analysis by laser-induced breakdown spectroscopy in agriculture: A review, *Trends in Analytical Chemistry* (2016), <http://dx.doi.org/doi: 10.1016/j.trac.2016.08.015>.

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1 **Challenging applications for multi-element analysis**  
2 **by laser-induced breakdown spectroscopy in**  
3 **agriculture: A review**

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9 **Highlights**

- 10 • We reviewed the commonly used LIBS instruments in agriculture.  
11 • Some signal enhancement methods were introduced to improve LIBS  
12 performance.  
13 • Calibration methods were introduced for quantitative analysis.  
14 • Recent applications of LIBS were reviewed in soil, plants, agricultural  
15 products and food.

16 **Abstract:** Toxic metal contamination and nutritious elements detection are two  
17 main issues in agriculture, as **these relate to** the development of agriculture and human  
18 health. Among the investigated techniques, laser-induced breakdown spectroscopy  
19 (LIBS) has the potential to become a fast and effective analytical tool for the  
20 application in agriculture. Herein is a review of the recent developments and  
21 applications of LIBS in the field of agriculture. We discussed the LIBS instruments  
22 and quantitative analytical methods, and introduced signal enhancement methods for  
23 expanding the elements detection capability. For detailed aspects of applications, we  
24 reviewed the recent progress in soil, plants, agricultural products and food. To solve  
25 the severe “matrix effect” problem and to meet high demands in agriculture, we  
26 recommended the development of robust and practical LIBS instruments, exploiting  
27 the chemometric methods and signal enhancement methods for quantitative analysis.

28 **Keywords:** Agriculture; Agricultural products and food; instruments; Laser-induced  
29 breakdown spectroscopy; Nutrient elements; Plants; Precision agriculture; Soil; Toxic  
30 metals

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