Plant Nutrition Management in Sustainable Agriculture

农业持续发展中的植物养分管理

李华栋／主编

江西出版集团·江西人民出版社

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江　西　省　科　学　技　术　协　会
国　际　植　物　营　养　研　究　所
江　西　省　农　业　科　学　院
中　国　植　物　营　养　与　肥　料　学　会
中国农业科学院农业资源与农业区划研究所

Jiangxi Association for Science and Technology
International Plant Nutrition Institute
Jiangxi Academy of Agricultural Sciences
Chinese Society of Plant Nutrition and Fertilizer Science
Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences

江西出版集团　　江西人民出版社
Jiangxi Publishing Group　　Jiangxi People's Publishing House

图书在版编目(CIP)数据

农业持续发展中的植物养分管理/李华栋主编.
—南昌:江西人民出版社,2008.9
ISBN 978-7-210-03932-7
Ⅰ.农… Ⅱ.李… Ⅲ.土壤有效养分—综合管理
Ⅳ.S158.3

中国版本图书馆 CIP 数据核字(2008)第 153782 号

农业持续发展中的植物养分管理
李华栋 主编
江西人民出版社出版发行
江西劳联印刷厂印刷 新华书店经销
2008 年 9 月第一版 2008 年 9 月第一次印刷
开本:889 毫米×1194 毫米 1/16 印张:42.5
字数:1340 千 印数:1-3000 册
ISBN 9787-7-210-03932-7 定价:85.00 元

江西人民出版社地址:南昌市三经路 47 号附 1 号
邮政编码:330006 传真:6898827 电话:6898893(发行部)
网址:www.jxpph.com E-mail:jxpph@tom.com web@jxpph.com

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前 言

植物养分是植物生长的物质基础，在农业持续发展中发挥着非常重要的作用。随着人地矛盾和生态环境安全问题的日益突出，如何加强养分管理，提高养分的有效利用，对提高作物产量、解决粮食问题、保护农业生态环境将起到决定性的作用。全世界的植物营养科学家在提高农作物生产、土壤生产力、环境质量及肥料利用率等领域进行了广泛的基础研究、应用研究和技术推广，取得了令人瞩目的成就。

为了促进植物与肥料有关的科学技术在养分资源管理中的应用，确保农业生产系统的可持续发展，江西省科学技术协会、国际植物营养研究所、江西省农业科学院、中国植物营养与肥料学会、中国农业科学院农业资源与农业区划研究所等有关单位于 2008 年 10 月 13 日至 16 日在江西南昌联合举办“农业持续发展中的植物养分管理国际学术研讨会”。与会国内外专家学者围绕农业持续发展中的植物养分管理这一主题，就土壤测试及推荐施肥技术、土壤有机无机养分资源管理、施肥与土壤质量、施肥及其对环境的影响、施肥与作物 / 农产品质量、精确养分管理及精确施肥技术等内容开展广泛的学术交流与研讨，提出建设性的意见和建议。

本次研讨会得到了江西省科学技术协会、国际植物营养研究所、中国植物营养与肥料学会、加拿大钾肥公司（Canpotex）、江西省农业科学院、中国农业科学院农业资源与农业区划研究所、广东省农业科学院土壤肥料研究所等单位的赞助和支持，得到了朱兆良、赵其国、刘更另、颜龙安等院士的指导，大会组织委员会在此深表感谢。

本次研讨会共收到来自中国、美国、加拿大、阿根廷、英国、菲律宾、埃及、新加坡、韩国、日本、波兰等国的专家学者撰写的论文 96 篇。现将这些论文结集出版，旨在共享经验和相互借鉴，共同促进植物营养学科的发展，为全世界农业的可持续发展作出应有的贡献。

编 者

2008 年 10 月

Preface

Plant nutrients, as the basic materials of plant production, played a vital role in the agricultural sustainable development. Along with the increasing of the contradiction between population and arable land area, and the ecological environment security problem, how to improve nutrients management and the nutrients use efficiency have become the key problems for increasing crop yield and protecting the ecological environment of agriculture. The plant nutrition scientists in the world are having devoted in wide basic and applied research and technical extension in the fields for improving crop production, soil productivity, environment quality, fertilizer use efficiency and have achieved great achievements.

To promote the application of science and technology that involved in plant and fertilizers in nutrient resources management and the development of sustainable agricultural production, an international symposium on nutrients management in sustainable agriculture was jointly held by Jiangxi Association of Science and Technology, International Plant Nutrition Institute, Jiangxi Academy of Agricultural Sciences, Chinese Society of Plant Nutrition and Fertilizer Science, Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences in Nanchang City, Jiangxi Province of China from 13th to 16th of October, 2008. Based on the symposium theme of "plant nutrition in sustainable agriculture", the participant made discussion, exchange and suggestion in several topics such as soiltesting and fertilizing recommend technology, organic and inorganic fertilizer resources management, effect of fertilization to soil quality, environment and crop quality, site specific nutrition management and technology.

This symposium obtained great financial and organize support from Jiangxi Association of Science and Technology, International Plant Nutrition Institute, Chinese Society of Plant Nutrition and Fertilizer Science, Jiangxi Academy of Agricultural Sciences, Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences, Institute of Soil and Fertilizer of Guangdong Academy of Agricultural Sciences. It also obtained valuable instruction from the Chinese academicians named Zhu Zhaoling, Zhao Qiguo, Liu Gengling and Yan Longan. The symposium organizing committee would like to take this opportunity to thank all of the supporters.

This symposium totally received 96 papers coming from China, USA, Canada, Argentina, Britain, Philippines, Egypt, Singapore, Korea, Japan and Poland. The papers were edited and published for sharing the positive results, promoting the development of plant nutrient discipline.

Editing committee

October, 2008

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A global framework for Best Management Practices for fertilizer use※

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This paper describes a framework designed to facilitate development and adoption of best management practices (*BMPs*) for fertilizer use, and to advance the understanding of how these practices contribute to the goals of sustainable development. The framework guides the application of scientific principles to determine which BMPs can be adapted to local conditions at the practical level.

At the practical level, cropping systems are managed for multiple objectives. Best management practices are those that most closely attain those objectives. Management of fertilizer use falls within a larger agronomic context of cropping system management. A framework is helpful for describing how BMPs for fertilizer use fit in with those for the agronomic system.

The goals of sustainable development, in the general sense, comprise equal emphasis on economic, social, and ecological aspects (Brundtland, 1987). Such development is essential to provide for the needs of current and future generations. On the practical level, however, it is difficult to relate specific crop management practices to these three general aspects. Four practical management objectives are applicable to the practical farm level of all cropping systems (Witt, 2003). These four objectives are productivity, profitability, cropping system sustainability, and a favorable biophysical and social environment (PPSE). They relate to each other as illustrated in Figure 1.

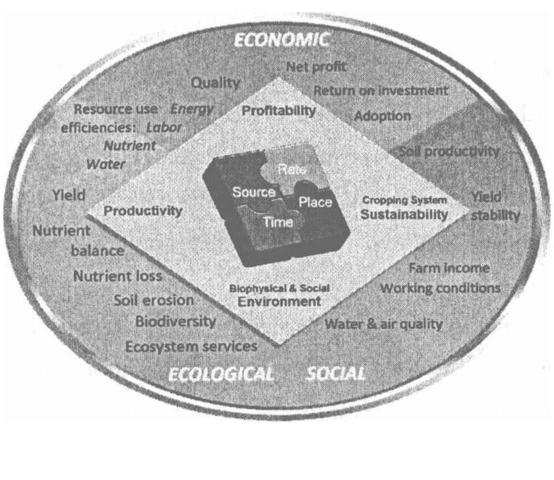

Figure1 A global framework for best management practices (BMPs) for fertilizer use. *Fertilizer use BMPs—applying the right nutrient source at the right rate, time, and place—integrate with agronomic BMPs selected to achieve crop management objectives of productivity, profitability, sustainability, and environmental health. A balanced complement of indicators is needed to reflect the influence of fertilizer BMPs on the four crop management objectives at the farm level, and on the economic, ecological and social goals for sustainable development on the broader scale for regional public policies.*

Fertilizer use BMPs comprise an interlinked subset of crop management BMPs. For a fertilizer use

※This paper is also presented on the IPNI website as a Concept Paper describing Global fertilizer BMP development work by IPNI. See:http://www.ipni.net/ipniweb/portal.nsf/0/88BDE1CF66B7BE52852573F0004EC075。

practice to be considered "best" , it must harmonize with the other agronomic practices in providing an optimum combination of the four objectives, PPSE. It follows that the development, evaluation, and refinement of BMPs at the farm level must consider all four objectives, as must selection of indicators reflecting their combined impact at the regional, national, or global level. Appropriate indicators for use at different scales are further discussed below in the section on performance indicators.

Cropping System Management Objectives

Productivity. For cropping systems, the primary measure of productivity is yield per unit area of cropland per unit of time. The quality of the yield is part of the productivity measure. Both can influence profitability, through volume and value, respectively. Productivity should be considered in terms of all resources, or production factors, involved. Multiple efficiencies can and should be calculated to accurately evaluate productivity.

Profitability. Profitability is determined by the difference between the value and the cost of production. Its primary measure is net profit per unit of cropland per unit of time. The profitability impact of a specific management practice is the amount of increase in gross revenue it generates, less its cost.

Sustainability. Sustainability—at the level of the cropping system—refers to the influence of time on the resources involved. A sustainable production system is one in which the quality (or efficiency) of the resources used does not diminish over time, so that "outputs do not decrease when inputs are not increased" (Monteith, 1990).

Environment (biophysical and social). Crop production systems have a wide range of effects on surrounding ecosystems through material losses to water and air. Specific effects can be limited or controlled by practices designed to optimize efficiency of resource use. However, not all effects are controlled to the same level. Some environmentally important losses, like those of phosphorus (P) or nitrous oxide, involve only a small fraction of the input applied. Others like ammonia emission or denitrification may involve large losses, and they are largely controlled by consideration of impacts on profitability. Environmental health and sustainability are intertwined. Management choices at the farm level, when aggregated, also influence the social environment through demand for labor, working conditions, changes in ecosystem services, etc.

Fertilizer Management Objectives

Fertilizer management objectives are essentially to support the four objectives identified for cropping systems management. Fertilizer use BMPs can be aptly described as the selection of the right source for application at the right rate, time, and place (Roberts, 2007). Specific scientific principles apply to these BMPs as a group and individually. These principles are both global and applicable at the farm management level. The application of these scientific principles may differ widely depending on the specific cropping system (region and crop combination) under consideration.

Fertilizer source, rate, timing and placement are interdependent, and are also interlinked with the set of agronomic management practices applied in the cropping system, as illustrated in Figure 1. In addition, the relative priority among the four management objectives (PPSE) varies according to local conditions. These priorities will guide the degree to which each of the scientific principles is reflected in the choice of BMPs.

Scientific Principles

1) Crop Management BMPs (includes all fertilizer BMPs)
   a) Seek practical measured validation.

i) Applied field testing should reflect effects on all four crop management objectives (PPSE), with control for natural sources of variability through replication and randomization, verified by peer-reviewed publication in appropriate science literature.

ii) Specify claimed benefits in clear language, identifying necessary context and associated costs, risks, and drawbacks.

b) Recognize and adapt to risks.

i) Weather, pests, socioeconomic conditions influence management practices, crop growth, nutrient uptake, and response to fertilizers.

c) Define performance indicators.

i) Using a participatory process, identify practical measurements that describe local impact on all four crop management objectives (PPSE).

d) Ensure two-way feedback between the global scale and the practical farm level.

i) "BMPs are dynamic and evolve as science and technology expands our understanding and opportunities, and practical experience teaches the astute observer what does or does not work under specific local conditions" (Fixen, 2007). Decision support guiding the adoption of fertilizer BMPs requires a dynamic process of local refinement (Figure 2). Involvement of individuals knowledgeable in both scientific principles and local conditions is important to this process. Palis et al. (2007) emphasized the importance of building on farmer knowledge, experiential learning, and social capital for ensuring adoption of fertilizer BMPs for small scale farmers in Asia.

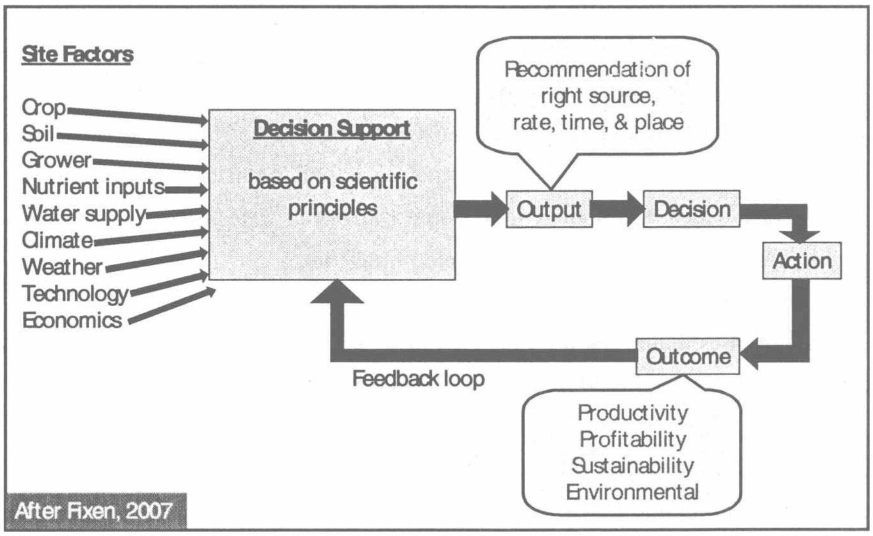

Figure 2 *Decision support for the development, evaluation, and adaptation of fertilizer BMPs requires a dynamic process of local refinement.*

2) Fertilizer BMPs (includes source, rate, place, and time)

a) Be consistent with understood process mechanisms.

i) Specific to the scientific disciplines of soil fertility, plant nutrition, soil chemistry, hydrology, agrometeorology, etc.

b) Recognize interactions with other cropping system factors.

i) Examples include cultivar, planting date, plant density, crop rotation, etc.

c) Recognize interactions among nutrient source, rate, time and place.

i) For example, a controlled-release source need not be applied with the same timing as a water-soluble source.