

# Guide to Laboratory Establishment for Plant Nutrient Analysis



**M.R. Motsara**  
**R.N. Roy**



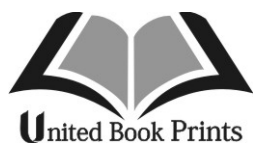
# Guide to Laboratory Establishment for Plant Nutrition Analysis

**M.R. Motsara**

*New Delhi, India*

***R.N. Roy***

*Rome, Italy*



*1st Reprint in India, 2015*

*Published by:*

United Book Prints  
4806/24, Ansari Road,  
Daryaganj,  
New Delhi - 110 002  
Tel.: 011-41511055  
E-mail: unitedbookprints@gmail.com

© *FAO, 2008*

*Print: 2015*

ISBN: 978-93-83692-09-5

eISBN: 978-93-88148-33-7

Printed in India

# Contents

<b>Acknowledgements</b>	<b>ix</b>
<b>Preface</b>	<b>xi</b>
<b>List of acronyms, abbreviations and chemical symbols</b>	<b>xiii</b>
<b>1. Introduction</b>	<b>1</b>
<b>2. The basics of an analytical laboratory</b>	<b>4</b>
Laboratory safety measures	5
Laboratory quality assurance/control	7
Standard operating procedure	9
Error, precision, accuracy and detection limit	9
Quality control of analytical procedures	11
Preparation and standardization of reagent solutions	16
<b>3. Soil analysis</b>	<b>23</b>
Available nutrient content of soils	23
Soil sampling	24
Dispatch of soil samples to the laboratory	28
Preparation of soil samples for analysis	28
Analytical methods	30
<b>4. Plant analysis</b>	<b>109</b>
Sample collection and preparation for analysis	114
Analytical methods	115
<b>5. Water analysis</b>	<b>128</b>
Important characteristics of irrigation water	128
Collection of water samples	132
Analytical methods	132
<b>6. Mineral and organic fertilizer analysis</b>	<b>143</b>
Sample collection and preparation	144

Analytical methods	146
<b>7. Biofertilizer assay and production</b>	<b>175</b>
Types of microscopes and their use in the laboratory	176
Examination of microbes by staining techniques	179
Culture media	182
Isolation and identification of important microbes	190
Inoculation of culture medium	198
Fermentation	199
Measurement of microbial growth	200
Quality control of biofertilizers	205
Commercial production of biofertilizers	210
<b>References and further reading</b>	<b>216</b>
<b>Annexes</b>	
1. Floor plan of a soil, plant, water and fertilizer analysis laboratory	223
2. Floor plan of a biofertilizer laboratory and production unit	224
3. Items required for a soil, plant and water analysis laboratory	225
4. Items required for a fertilizer testing laboratory	234
5. Items required for a microbiological laboratory	235
6. Summary of plant nutrient estimation methods	246
7. Automation of analytical procedures	248
8. Examples of laboratory registers	261
9. Grades of chemicals and glassware	263
10. Equivalent and molecular weights of compounds	265
11. Soil sample information sheet	267
12. Colour change of solutions owing to pH change	268
13. Glossary of biofertilizer terms	270
14. Units and conversion factors	276

# List of tables

1. Laboratory types, with analysis capacity
2. Strength of commonly used acids and alkalis
3. Data sheet for recording hydrometer readings
4. Soil reaction ratings
5. Lime required to reduce soil acidity
6. Lime requirement for different pH targets
7. Chemical characteristics of saline, non-saline sodic and saline sodic soils
8. General interpretation of EC values
9. Wavelengths and corresponding colour ranges
10. Commonly used extractants for micronutrients
11. Critical limits for DTPA-extractable micronutrients
12. Parameters for estimation of micronutrients using an AAS
13. Specifications for preparing micronutrient standard solutions
14. General sufficiency or optimal range of nutrients in plants
15. Typical plant parts suggested for analysis
16. Critical nutrient concentrations for 90-percent yield for various crops
17. Parameters for micronutrient estimation by AAS
18. Suitability of irrigation water for semi-tolerant and tolerant crops in different soil types
19. Specifications of commonly used biofertilizers
20. Micro-organism-specific media
21. Plant nutrient solution
22. Chemicals required for the production of *Rhizobium* biofertilizer
23. Chemicals required for the production of *Azotobacter* biofertilizer
24. Chemicals required for the production of *Azospirillum* biofertilizer
25. Chemicals required for the production of PSMs





## List of figures

1. Soil texture classes according to proportions of sand, silt and clay
2. Standard curve for organic carbon on spectrophotometer
3. Standard curve for P on spectrophotometer
4. Standard curve for K on flame photometer
5. Standard curve for Zn on an AAS
6. Standard curve for Cu on an AAS
7. Standard curve for Fe on an AAS
8. Standard curve for Mn on an AAS



## **Acknowledgements**

The contribution of R.N. Roy to the conceptualization, initiation and inputs in the preparation and finalization of this publication is duly acknowledged. Special thanks are due to M.R. Motsara, who assisted FAO in several field projects related to this subject and contributed to shaping this document. Thanks also go to R.P. Thomas and P. Bhattacharyya for peer reviewing the chapters on soil and biofertilizer, respectively, and for their suggestions.



# Preface

This publication provides practical guidelines on establishing service laboratories for the analysis of soil, plants, water and fertilizers (mineral, organic and biofertilizers). A service laboratory needs information on a methodology that is widely acceptable, taking into consideration the ready availability of chemicals, reagents and instruments while ensuring a reasonable degree of accuracy, speed and reproducibility of results. The method needs to be easy to understand for practising technicians who are required to adopt it in a routine manner.

A manual, with simple procedural steps, is considered as providing the best help to the laboratory technicians. This publication provides various analytical methods for estimating soil constituents with the objective of assessing soil fertility and making nutrient recommendations. It describes methods for analysing plant constituents in order to determine the content of various nutrients and the need for their application. For assessing the quality of irrigation water, it presents standard methods for estimating the various parameters and constituents utilized,

e.g. electrical conductivity, sodium adsorption ratio, residual sodium carbonate, the ratio of magnesium to calcium, and boron content. In providing the methodology for fertilizer analysis, special consideration has been given to the fact that fertilizers are often statutorily controlled commodities and are traded widely among countries.

This guide also examines biofertilizers. It discusses the bacterial cultures that serve either as a source of nitrogen, such as *Rhizobium*, *Azotobacter* and *Azospirillum*, or for improving the availability of soil phosphorus, such as phosphate-

solubilizing microbes. It provides methods for their isolation, identification, multiplication and commercial production. The Reference section includes sources for further detailed information.

This guide details the equipment, chemicals and glassware required in order to establish a composite laboratory with facilities for soil, water and plant analysis. Similarly, it details the requirements for establishing a fertilizer testing laboratory and a biofertilizer testing/production laboratory. To save on the cost of some of the common equipment, facilities and supervision, the analytical facilities required for various materials can be combined. However, it is necessary to ensure that no contamination of the soil by the fertilizers or vice versa takes place. In view of this, even in a composite laboratory (which is otherwise desirable), it is necessary to keep rooms for processing and handling different types of samples separate from one another, while keeping them in close proximity in order to save on time for movement and supervision. The guide takes these considerations into account.

This publication should prove useful to administrators and planners in establishing laboratories, and to technicians through providing detailed and precise procedures for estimations.

# List of acronyms, abbreviations and chemical symbols

AAS	Atomic absorption spectrophotometer
Al	Aluminium
AOAC	Association of Official Analytical Chemists, the United States of America
AR	Analytical reagent
As	Arsenic
B	Boron
BAC	Benzalkonium chloride
BGA	Blue-green algae
BOD	Biochemical oxygen demand
C	Carbon
Ca	Calcium
CEC	Cation exchange capacity
Cl	Chlorine
Co	Cobalt
COD	Chemical oxygen demand
CP	Chemically pure
CRYEMA	Congo red yeast extract mannitol agar
Cu	Copper
DAP	Di-ammonium phosphate
DDW	Double-distilled water
DTPA	Diethylenetriamine pentaacetic acid
EBT	Eriochrome Black T
EC	Electrical conductivity
EDTA	Ethylenediamine tetraacetic acid
Eq W	Equivalent weight

Fe	Iron
GLP	Good laboratory practice
H	Hydrogen
H <sub>2</sub> SO <sub>4</sub>	Sulphuric acid
HCl	Hydrochloric acid
HEPA	High-efficiency particulate air
Hg	Mercury
ICP	Inductively coupled plasma
ICP–AES	Inductively coupled plasma – atomic emission spectroscopy
INM	Integrated nutrient management
IPE	International Plant Analytical Exchange
ISE	International Soil Analytical Exchange
ISO	International Organization for Standardization
K	Potassium
LR	Laboratory reagent
M	Molar
MARSEP	International Manure and Refuse Sample Exchange Programme
mcf	Moisture correction factor
me	Milli-equivalent
mEq W	Milli-equivalent weight
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
MOP	Muriate of potash
N	Nitrogen
NaOH	Sodium hydroxide
Ni	Nickel
O	Oxygen
OM	Organic matter
P	Phosphorus
PSM	Phosphate-solubilizing micro-organism
RSC	Residual sodium carbonate
S	Sulphur



SAR	Sodium adsorption ratio
Se	Selenium
SETOC	International Sediment Exchange for Tests on Organic Contaminants
SOM	Soil organic matter
SOP	Standard operating procedure
SOP	Sulphate of potash
SSP	Single superphosphate
STPB	Sodium tetraphenyl boron
TEA	Triethanolamine
UV	Ultraviolet
WEPAL	Wageningen Evaluating Programme for Analytical Laboratories
WHC	Water holding capacity
YEMA	Yeast extract mannitol agar
Zn	Zinc