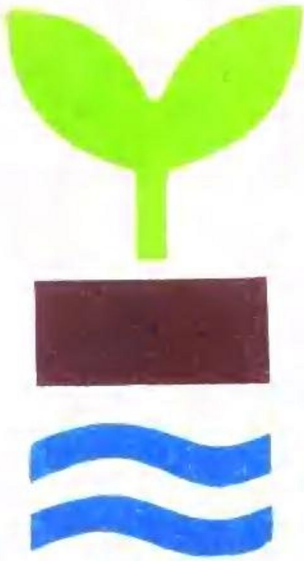
由懋正　王会肖　著

国家自然科学基金资助项目



农田土壤水资源评价

气象出版社

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内 容 简 介

本书是我国第一部讨论土壤水资源的专著。全书共分四章，从农田水分循环和水量平衡的基本原理出发，论述了陆地水资源系统和土壤水资源的评价原则与方法，首次尝试了区域土壤水资源和作物土壤水资源的数量评价，全面系统地阐述了农田土壤水资源利用和保护的途径与措施。

本书内容丰富新颖，对合理利用农业水资源和提高水分利用效率等有重要理论与实际意义，可供水文水资源、农业、地理等方面的科研、教学人员参考。

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由懋正　王会肖　著

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序　言

土壤水资源的提法曾有争议，80年代我国的全国水资源评价中也未列入资源计算。但是，随着农业的利用和对土壤水分的深入研究，越来越多的学者认识到土壤水的资源性。1983年以来，前苏联科学院水问题研究所的А. И. Будаковский和Н. А. шумова连续撰文阐明土壤水资源在水利经济决策中的作用，从应用方面发展了M. I. L'vovitch1980年提出的“水文学中土壤趋向”(Soil Trend in Hydrology）一文的思想。嗣后，笔者在1988年科学出版社出版的“水量转换——实验与计算分析”一书中也论述了“土壤水的资源评价”问题，展开讨论了土壤水的资源论证、评价计算与调控指标。1992年国家自然科学基金委在“八五”重大项目“华北平原节水农业应用基础研究”与面上基金都选择了土壤水资源利用评价的研究。本书是国家自然科学基金委资助的一个项目。

本书密切联系农业生产的实际，在中国科学院石家庄农业现代化研究所的栾城与南皮等生态站点布置了土壤水及其参数的观测与实验，并且广泛调查了我国北方其它一些地区土壤水分研究进展。根据重点试验与面上的调查，较为全面地论述了农田土壤水资源评价的主要问题。本项研究的目的明确，内容系统，含积累多年的土壤水分试验研究资料。在理论与实际相结合基础上提出的农田土壤水资源评价的方法与原理，促进了土壤水资源研究的科技进步，有益于土壤水资源的农业利用和发展农业生产。

刘昌明

1996年元月

前　言

作为自然资源的水资源对于国民经济建设和人类社会进步的重要性是不言而喻的，然而，水资源又是一种有限的自然资源，有限的资源和日益增长的需要之间的矛盾即水资源供需矛盾日益尖锐。本世纪60年代以来，各国陆续开展水资源的评价、开发和利用的研究工作。

水资源评价始于地表水资源和地下水资源评价研究。在对地表水和地下水评价的基础上，扣除其相互转化的重复部分，求得一个流域或区域的水资源总量即当地降水形成的地表和地下的产水量，这就是迄今为止的水资源概念及其基本评价方法，我们称之为传统水资源。传统水资源是重力水资源，它可以通过引水、输水、提取、蓄存和循环使用等多种形式满足各方面的用水需要。传统水资源是十分宝贵的自然资源，人类应当十分珍惜和精心保护它。我国和世界其他国家的水资源评价给出的结果就是对传统水资源的评价。

从陆地水分循环过程可知，如果我们忽略某些细节，则陆地水分循环系统的水分收入是大气降水，它最终转化为地表水、土壤水和地下水三种形式，它们共同组成陆地水资源系统。就是说，一个流域或较大区域的天然水资源量是其降水量，它等于地表水、土壤水和地下水资源之和。地表水和地下水资源为重力水资源，经过多年的研究，对它们的评价学术界已取得基本一致的认识，并且成功地为用水部门提供了科学依据。

尽管土壤水早就为陆地植被（包括作物）所利用，受到农学家和农民的高度重视，但是土壤水是否属于水资源范畴，和如何进行数量评价，研究家们尚未取得共识，甚至使用土壤水资源术

语的学者，对其内涵的理解也不尽一致。因此我们抱着学习、交流的愿望，对土壤水资源的评价进行初步分析和探讨，以求认识的深化。

我们以中国科学院栾城生态站（代表华北山前平原）为重点进行观测试验，并收集南皮站、禹城站和封丘站的有关资料，分析华北平原土壤水资源。同时，还利用了中国科学院海伦站（代表东北松嫩平原黑土区）和长武站（代表黄土高原旱作农田）的试验资料，以了解东北平原和黄土高原的情况。

本书共分四章。第一章在简单介绍了传统水资源之后，提出陆地水资源系统概念，认为土壤水资源是区域水资源不可缺少的组成部分，给出了区域水资源结构的表达式。这一章还重点回顾了国内外学者对土壤水资源的认识和研究进展。本世纪 80 年代初，前苏联学者和我国学者几乎同时开始探讨土壤水资源问题，这是农业生产实践特别是旱地农业提出的水资源研究新课题。

第二章讨论农田水量平衡和土壤水分动态问题，这是农田土壤水资源评价的基础。分别讨论了农田土壤水分的各个补给项和支出项的观测和计算方法，给出了我国北方不同生态类型地区（东北松嫩平原、黄土高原和华北平原）典型农田的水量平衡及其水分动态变化的特征。

第三章是本书的核心内容。首先分析了土壤水库的蓄水条件和调节能力，给出我国北方几个地点土壤水库的蓄水能力和不同季节的有效库容。在论述农田土壤水资源评价原则中，强调应区分土壤蓄水量和水分循环量的差别，作为参与水分循环的土壤水，用根系层土壤水分的补给量或消耗量来评价它的资源量是符合水量平衡原理的。土壤水资源评价分为区域评价和作物评价，多年平均流域水量平衡方程式是区域土壤水资源评价的基本方法，流域总蒸发量或者确切地说蒸散量是区域土壤水资源的数量评价。土壤水的资源价值在于植被（包括作物）利用，而作物生育期一般是一年的某一时期，因此，农田的蒸散量包括作物生育期内的

水分补给量和土壤水利用量，据此，给出了研究期间不同类型地区主要作物的土壤水资源评价的初步结果。农田蒸散量包括作物蒸腾和土壤水蒸发两部分，它们表征土壤水资源的结构。

土壤水的利用和保护是土壤水资源研究的重要内容。第四章分别讨论了作物根系生长与吸水规律、作物耗水量及优化用水、作物水分利用率（WUE）以及农田覆盖和土壤耕作与土壤水分利用的关系等，对土壤水的合理利用和保护将能提高作物水分利用效率，达到节水增产高效的目的。

本项研究得到了国家自然科学基金的资助。刘昌明院士经常关心和指导这项研究工作。袁小良副研究员参加了本课题研究，负责栾城站的田间试验工作。在课题研究过程中，张喜英副研究员、尹雁峰博士多次为我们提供和整理资料，共同探讨有关问题；野外观测和试验工作得到栾城站王绍仁站长、吕富保副站长以及海伦站、长武站领导的支持和帮助；胡南燕同志帮助清绘插图。在此我们一并表示衷心的感谢。

作者

1995 年 12 月　石家庄

Foreword

Water resources, as a kind of natural resources is of great importance for the national economic establishment and the progress of human society. However, water resources is a natural resource with the limited amount and the contridiction between the limited resource and the evergrowing need, i. e. that between need and supply of water resources is increasingly acute. Since 1960' s, the research work on the assessment, development and utilization of water resources has carried out in different regions of the world.

Assessment on water resources began with the evaluating work on surface water resources and underground water resources. Based the evaluation of surface water and underground water and deducting the overlapping part during the inter-transformation, the total amount of water resources calculated in a catchment or a region, i. e. locally formed surface water and underground water yield, exactly is the concept of water resources and its basic appraising method and is to be called traditional water resources. The traditional water resources is gravitational water resources and it can meet the water use requirements in different aspects through diversion, conveyance, pumping, storage and circulating use, etc. The traditional water resources is a kind of very valuable natural resources, so people should cherish it and elaborately protect it. The results given by water resources assessment in China and other countries in the world are exactly the evaluation on the traditional water resources.

Known from the process of land water cycle, if some details are ignored, the input of land water cycle system is atmosphere precipitation which finally transforms into three types, such as surface water, soil water and underground water jointly composing the land water resources system. In another words, the natural water resources in a catchment or a relatively large region is the local precipitation, which equals to the sum of surface water, soil water and underground water. Through many years' study, the identical understanding on the assessment of surface water and underground water resources has already acquired in the academic circles. And the assessment successfully provides scientific basis for water use department.

Though soil water has been used by land vegetation (including crops) and has been given great attention by agronomists and farmers, the common ideas on the issues whether soil water belongs to the category of water resources and how to evaluate it quantitively have not been gained. Even the scholars who use the term of soil water resources have not got the agreement on understanding its connotation. The preliminary analysis and discussion on the assessment of soil water resources has carried out in the want of the study and idea exchanging in order to deepen the understanding on soil water resources assessment.

We carried out the experiments and observations taking Luancheng Ecological Station, Chinese Academy of Sciences (CAS) representing the piedmont plain of North China as a case study site and also collected the related data from Nanpi Station, Yucheng Station and Fengqiu Station to analyse the soil water resources in the North China Plain. At the same time, we also analysed the experimental data from Hailun Station, CAS repre-

senting black earth region in Northeast Songnen Plain and Changwu Station representing the dry farmland in the Loess Plateau to know the situation of the Northeast Plain and the Loess Plateau.

This book is totally divided into four chapters. After simply introducing traditional water resources, the concept of land water resources system is put forward in Chapter I. The authors consider that soil water resources is an essential part of regional water resources and give the expressing formula of the regional water resources structure. The understanding and research advances at home and abroad on soil water resources have stressedly reviewed in this chapter. At the beginning of the 1980' s, almost at the same time the issue on soil water resources began to be explored both in Russia and in China. This is a new project on water resources research proposed by the agricultural production practice, especially the dryland agriculture.

The issues on field water balance and soil water dynamics are discussed in Chapter Ⅱ, which is the basis for the evaluation of field soil water resources. The observation and calculating methods for the inputs and outputs of field soil water are discussed separately. The water balances of typical farmlands and their characteristics of soil water dynamics in the different ecological regions in northern China (the Northeast Songnen Plain, the Loess Plateau and the North China Plain) have been given.

In Chapter Ⅲ, the heart of this book, the storaging conditions and regulating capacity of soil water reservoir are firstly analysed to give the storage capacity of soil water reservoir and the effective reservoir size in different seasons in several places of northern China. In the exposition of the principle for field soil

water resources assessment, the difference in soil water storage and soil water circulating amount is stressed. Soil water involves in water cycle, so using the soil water recharge and consumption in root zone for evaluating its resource amount conforms to water balance theory. Assessment on soil water resources includes regional and crop evaluation. The catchment water balance equation at many year's average level is the basic method for evaluating regional soil water resources. The total catchment evaporation or precisely evapotranspiration is the quantitive evaluation for regional soil water resources. The resource value of soil water depends on vegetation (including crops) use, but generally crop growth season is just a period in a year. Therefore, field evapotranspiration includes water recharge within crop growth period and soil water consumption. According to this, the preliminary results on soil water resources assessment for major crops in different types of region during research period (1991—1994) are given. Field evapotranspiration includes crop transpiration and soil water evaporation which show the structure of soil water resources.

The utilization and protection are the important contents in the researches of soil water resources. The crop root growth and water uptake patterns, crop water consumption and optimal water use, crop water use efficiency (WUE), and the relationship between land cover, soil tillage and soil water use, etc. are discussed separately in Chapter Ⅳ. The reasonable use and protection of soil water can raise crop water use efficiency to reach the aims of water-saving, high yield, and high benefit.

This research project is subsidized by the National Natural Science Foundation Committee. Academician Liu Changming fre-

quently cares for and gives instructions for this research work. Associate professor Yuan Xiaoliang participated in this project study being in charge of the field experimental work at Luancheng Station. During the research, associate professor Zhang Xiying and Dr. Yin Yanfeng have provided and sorted out data for us and discussed the related issues together with us. Director Wang Shaoren, deputy director Lu Fubao of Luancheng Station and the leaders of Hailun Station and Changwu Station have given us great support and help for the field experiments and observations. We would like to express our heartfelt thanks to them all.

The authors

Dec. 1995 in Shijiazhuang

目　录

Contents