

Cactus (*Opuntia* spp.) as forage

FAO
PLANT
PRODUCTION
AND PROTECTION
PAPER

169



Food
and
Agriculture
Organization
of
the
United
Nations



Cactus (*Opuntia* spp.) as forage

FAO
PLANT
PRODUCTION
AND PROTECTION
PAPER

169

Edited by

Candelario Mondragón-Jacobo

Instituto Nacional de Investigaciones Forestales y
Agropecuarias (INIFAP)

Mexico

and

Salvador Pérez-González

Universidad Autónoma de Querétaro

Mexico

Coordinated for FAO by

Enrique Arias

Horticultural Crops Group

Stephen G. Reynolds

Grassland and Pasture Crops Group

FAO Plant Production and Protection Division

and

Manuel D. Sánchez

Feed Resources Group

FAO Animal Production and Health Division

Produced within the framework of the

FAO International Technical Cooperation Network

on Cactus Pear

Food
and
Agriculture
Organization
of
the
United
Nations



Rome, 2001

Reprinted 2002

The designations “developed” and “developing” economies are intended for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country, country territory or area in the development process.

The views expressed herein are those of the authors and do not necessarily represent those of the Food and Agriculture Organization of the United Nations or of their affiliated organization(s).

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

ISBN 92-5-104705-7

All rights reserved. Reproduction and dissemination of material in this information product for educational or other non-commercial purposes are authorized without any prior written permission from the copyright holders provided the source is fully acknowledged. Reproduction of material in this information product for resale or other commercial purposes is prohibited without written permission of the copyright holders. Applications for such permission should be addressed to the Chief, Publishing and Multimedia Service, Information Division, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy or by e-mail to copyright@fao.org

© FAO 2001

FOREWORD

The cactus *Opuntia* has been used in Mexico from pre-Hispanic times, and along with maize (*Zea mays*) and agave (*Agave* spp.), played a major role in the agricultural economy of the Aztec civilization.

In recent years there has been increased interest in *Opuntia* species for the important role they play – and are likely to play – in the success of sustainable agricultural systems in marginal areas of arid and semi-arid zones.

Opuntias are well-adapted to arid zones characterized by droughty conditions, erratic rainfall and poor soils subject to erosion, having developed phenological, physiological and structural adaptations to sustain their development in these adverse environments. Notable adaptations are their asynchronous reproduction, and their Crassulacean Acid Metabolism, enabling them to grow with very high efficiency under conditions of limited water.

While opuntias may particularly contribute in times of drought, serving as a life saving crop to both humans and animals, they also regularly provide livestock forage in arid and semi-arid areas. They provide highly digestible energy, water and minerals, and when combined with a source of protein, they constitute a complete feed.

In 1995 FAO published a book on *Agro-ecology, cultivation and uses of cactus pear*, prepared through CACTUSNET, the international cactus network, with only one chapter devoted to the use of opuntia as feed. The present publication, also prepared through CACTUSNET, focuses primarily on the use of opuntia as forage and presents many recent research and development findings.

The preparation of this book was coordinated by Enrique Arias and Stephen Reynolds of the Horticulture and Grassland and the Pasture Crops Groups of the Plant Production and Protection Division, and by Manuel Sanchez of the Feed Resources Group of the Animal Production and Health Division.

E. Kueneman
Chief, Crop and Grassland Service
Plant Production and Protection Division
H. Kudo
Chief, Animal Production Service
Animal production and health division

PREFACE

Towards the end of 1990, encouraged by the Mexican Embassy in Rome, a Mexican delegation consisting of researchers, technicians and officials from the federal agricultural sector, visited the island of Sicily, Italy, with the aim of initiating agreements to exchange information between the two countries concerning the cultivation and utilization of opuntia. When the delegation arrived on the island, the spectacular development of opuntia was noted. It was surprising to realize that formal cultivation of opuntia started only in the 19th century.

One year later, an *International Symposium on Opuntia*, with participants from Chile, Italy, Mexico and USA, was organized in Lagos de Moreno (Jalisco, Mexico), with the purpose of encouraging producers and researchers to increase cooperation among the participating countries and to diffuse information on the importance of opuntia.

As a follow-up to this meeting, it was proposed to create an International Technical Cooperation Network on Cactus Pear (CACTUSNET). The proposal was presented in a special session of the *Second International Congress on Opuntia*, which was held in Santiago, Chile, in 1992. CACTUSNET was established under the auspices of the Food and Agriculture Organization of the United Nations (FAO) in a specific meeting organized by the University of Guadalajara, Mexico, in August 1993, with the participation of ten countries from the Americas, Asia and Europe. Subsequently, several African countries have also joined the Network.

Subsequently, thanks to the voluntary cooperation of CACTUSNET members residing in countries with an arid environment, it was possible to start a database on countries of production, opuntia uses, and cultivated areas. At the end of the 20th century, the area under cultivated opuntia for forage was reported to be 900 000 ha, greatly surpassing the reported area for fruit (100 000 ha). For farmers in arid zones, opuntia planting is one solution to the problem of recurrent droughts. The succulence and nutritive value of opuntia make it a valuable emergency crop, permitting livestock farmers in Brazil, Mexico, South Africa and USA to survive prolonged and severe droughts.

It is worth mentioning that most authors of this book are technicians and scientists with wide experience in their own country of cultivation and use of opuntia as forage. The publication strengthens the written information on opuntia, since most of the existing publications have emphasized its use as a fruit.

Finally, I would like to mention that the diffusion of information on species like opuntia can allow assessment of its value for tackling drought in the short term, while in the medium term opuntia can constitute an important alternative to counteract global climate change and desertification. Other benefits from opuntia are soil and water conservation, and protection of local fauna in arid and semi-arid lands.

The publication of this book is, therefore, opportune, reflecting one of the basic objectives of the CACTUSNET, namely the diffusion of technical and scientific knowledge on opuntia

Dr Eulogio Pimienta

University of Guadalajara, Mexico

First General Coordinator of the CACTUSNET

CONTENTS

Foreword	iii
Preface	iv
Acknowledgements	x
INTRODUCTION	1
GENERAL BACKGROUND ON OPUNTIA	1
BOTANY	1
TERMINOLOGY	2
CACTUSNET	3
OPUNTIA AS FORAGE	3
ENVIRONMENTAL ISSUES	4
PURPOSE OF THE BOOK	4
HISTORY OF THE USE OF OPUNTIA AS FORAGE IN MEXICO	5
Marco Antonio ANAYA-PÉREZ	
INTRODUCTION	5
ORIGIN	5
DISTRIBUTION	6
COLONIAL MEXICO	7
Description of the opuntia plant	7
Propagation	8
Livestock raising	9
Forage	9
INDEPENDENT MEXICO	10
Livestock husbandry	10
The forage	10
RECENT DEVELOPMENT OF OPUNTIA IN MEXICO	11
Forage	11
Opuntia production	12
ECOPHYSIOLOGY OF <i>OPUNTIA FICUS-INDICA</i>	13
Park S. NOBEL	
INTRODUCTION	13
DAILY GAS EXCHANGE	13
WATER-USE EFFICIENCY	14
WATER RELATIONS	15
TEMPERATURE RELATIONS	17
LIGHT RELATIONS	17
NUTRIENT RELATIONS	18
ATMOSPHERIC CO ₂	18
PREDICTED PRODUCTIVITIES	18
COMPARISONS WITH OTHER SPECIES	19
CONCLUSIONS	20

GERMPLASM RESOURCES AND BREEDING OPUNTIA FOR FODDER PRODUCTION	21
Candelario MONDRAGÓN-JACOBO and Salvador PÉREZ-GONZÁLEZ	
INTRODUCTION	21
BIOLOGICAL BASIS OF BREEDING	22
OPUNTIA BREEDING TECHNIQUES	22
LIMITATIONS TO BREEDING	23
GERMPLASM RESOURCES	23
Wild stock	23
Backyard sources	24
EARLY ATTEMPTS AT BREEDING OPUNTIA FOR FODDER	24
The improved Mexican cultivars	24
The 'Palmas of Brazil'	25
The spineless Burbank selections in South Africa	25
ACTIVE BREEDING PROGRAMMES	25
BREEDING GOALS	26
Cold Tolerance	26
Spineless pads	27
Plant productivity	27
High protein content	27
Pest and disease tolerance	27
IMPROVED OPUNTIA CULTIVARS BEYOND 2000	27
PRODUCTION AND USE OF OPUNTIA AS FORAGE IN NORTHERN MEXICO	29
Juan José LÓPEZ-GARCÍA, Jesús Manuel FUENTES-RODRÍGUEZ and R.A. RODRÍGUEZ	
OPUNTIA IN NORTHERN MEXICO	29
GEOGRAPHICAL DISTRIBUTION OF NOPALERAS	29
DISTRIBUTION OF THE MAIN FORAGE SPECIES	30
PRODUCTION	31
Wild stands	31
Cultivated nopaleras	31
HARVESTING SYSTEMS	32
CONSUMPTION BY ANIMALS	33
NUTRITIONAL VALUE	33
OPUNTIA AND ANIMAL PRODUCTION	35
Meat production	35
Milk production	35
Sheep	35
Other animals	36
PROBLEMS AND PERSPECTIVES	36
FODDER NOPAL USE IN THE SEMI-ARID NORTHEAST OF BRAZIL	37
Djalma CORDEIRO DOS SANTOS and Severino GONZAGA DE ALBUQUERQUE	
INTRODUCTION	37
CHARACTERIZATION OF LIVESTOCK PRODUCTION SYSTEMS	39
Planting density	39
Crop management	41

Soil preparation	41
Cutting height	42
Species comparison	42
Environmental constraints	43
Shading by mesquite (<i>Prosopis juliflora</i>)	43
Pests and diseases	43
Weed control	44
Economic evaluation	44
NUTRITIVE VALUE STUDIES	46
COMPARISON WITH OTHER FORAGES	46
COMPARISON AMONG CULTIVARS	46
STORAGE EFFECT	48
FINAL CONSIDERATIONS	49
UTILIZATION OF <i>OPUNTIA</i> FOR FORAGE	
IN THE UNITED STATES OF AMERICA	51
Peter FELKER	
INTRODUCTION	51
NUTRITIONAL PROPERTIES AND SUPPLEMENTATION REQUIREMENTS	52
METHODS TO INCREASE THE PROTEIN CONTENT OF CACTUS FORAGE	53
PLANTING, CULTIVATION, FERTILIZATION AND CARE	54
THORNLESS VERSUS THORNY CACTUS FORAGE VARIETIES	55
COMPARISON OF CACTUS WITH HAY	56
CONCLUSIONS	56
OPUNTIA USE AS FEED FOR RUMINANTS IN CHILE	57
Patricio AZÓCAR	
INTRODUCTION	57
CULTIVATION OF FORAGE OPUNTIA	58
Climate	58
Water requirement	58
Planting	58
Productivity	58
NUTRITIONAL QUALITY OF FORAGE OPUNTIA	59
EFFICIENCY OF WATER UTILIZATION IN DRYLAND ZONES	60
INTEGRATION OF CACTUS WITH OTHER NATURAL FEED	
RESOURCES OF ARID ZONES	61
<i>OPUNTIA</i> spp. FOR FODDER AND FORAGE PRODUCTION IN ARGENTINA: EXPERIENCES AND PROSPECTS	63
Juan C. GUEVARA and Oscar R. ESTÉVEZ	
INTRODUCTION	63
BIOCLIMATIC CLASSIFICATION OF THE ARID AND SEMI-ARID ZONES	63
MAIN CONSTRAINTS FOR CACTUS PLANTATIONS	66
Temperature	66
Rainfall	66
Land tenure	66
ABOVEGROUND BIOMASS PRODUCTIVITY	66
MICROPROPAGATION OF <i>OPUNTIA ELLISIANA</i>	67
ECONOMIC FEASIBILITY OF FORAGE OPUNTIA PLANTATIONS	67

Cattle production	67
Goats for meat production	69
PROSPECTS AND RECOMMENDATIONS	71
OPUNTIA SPP. - A STRATEGIC FODDER AND EFFICIENT TOOL	73
TO COMBAT DESERTIFICATION IN THE WANA REGION	
Ali NEFZAOUI and Hichem BEN SALEM	
INTRODUCTION	73
IMPORTANCE OF CACTI IN ARID ZONES	74
CACTI AS A FODDER BANK	74
USE OF CACTI AGAINST DESERTIFICATION IN NORTH AFRICA	75
USE OF CACTI AS FODDER	75
Chemical composition	75
Digestibility	79
EFFECT OF FEEDING CACTUS ON RUMEN FERMENTATION PATTERN	80
Rumen pH	81
Ammonia concentration	81
Volatile fatty acids	82
Protozoa counts	82
Cellulolytic activity	82
Intake	83
CACTUS FEEDING HELPS TO SOLVE THE PROBLEM OF	
WATERING ANIMALS IN ARID ENVIRONMENTS	84
Energy content	84
SOME PRACTICAL CONSIDERATIONS	84
STORAGE	84
GRAZING VERSUS CUT-AND-CARRY	85
SPINES	85
LAXATIVE EFFECTS – EASY TO SOLVE	85
INTEGRATION OF CACTI WITH OTHER ARID ZONES FEED RESOURCES	86
Example 1. Poor quality roughages supplemented with opuntia	86
Example 2. <i>Atriplex</i> as a nitrogen supplement to cactus	87
Example 3. Can acacia supplement cactus?	88
CONCLUSIONS	90
NUTRITIONAL VALUE OF <i>OPUNTIA FICUS-INDICA</i>	91
AS A RUMINANT FEED IN ETHIOPIA	
Firew TEGEGNE	
INTRODUCTION	91
ECOLOGICAL DISTRIBUTION AND	
UTILIZATION OF OPUNTIA IN ETHIOPIA	92
NUTRITIONAL VALUE OF <i>OPUNTIA FICUS-INDICA</i>	92
ANALYSIS OF ETHIOPIAN OPUNTIA	94
Dry matter, ash and mineral content determinations	94
Mineral composition	94
Chemical composition	96
<i>In vitro</i> dry matter digestibility	96
CHEMICAL COMPOSITION	97
CP content	97
Crude fibre content	97

Nitrogen-free extract content	97
<i>In vitro</i> dry matter digestibility	97
CONCLUSIONS	99
THE USE OF OPUNTIA AS A FODDER SOURCE	101
IN ARID AREAS OF SOUTHERN AFRICA	
Gerhard C. DE KOCK	
INTRODUCTION	101
CLIMATE	101
OPUNTIA CULTIVATION	101
WATER REQUIREMENT AND USE	102
PRODUCTION	103
CROP MANAGEMENT	104
UTILIZATION	104
Grazing	104
Chaffing	104
Meal	104
Silage	105
Supplementary feeding	105
LAXATIVE ACTION	105
CULTIVATION OF OPUNTIA FOR FODDER PRODUCTION:	107
FROM RE-VEGETATION TO HYDROPONICS	
Candelario MONDRAGÓN-JACOBO, Santiago de J. MÉNDEZ-GALLEGOS	
and Genaro OLMOS-OROPEZA	
INTRODUCTION	107
FACTORS ASSOCIATED WITH OPUNTIA FODDER PRODUCTION	108
The cladode as a water reservoir	108
Length of growing season	108
Propagation	108
Response to pruning	109
Response to fertilization	110
Response to high planting densities	110
EXTENSIVE CULTIVATION OF OPUNTIA FOR FORAGE	
IN ECOLOGICALLY-ORIENTED PROGRAMMES	111
MINIMUM REQUIREMENTS FOR EXTENSIVE PLANTATIONS	111
Site selection	111
Site protection	111
Planting material	111
Collection of planting material from wild stands	112
Planting techniques	112
Fertilization	112
Utilization	112
INTENSIVE CULTIVATION OF OPUNTIA FOR FORAGE PRODUCTION	112
Site selection	112
Land preparation	113
Cultivars	113
Propagation material	113
Plantation layout	113
Planting date	113

Fertilization	114
Weed control	114
Management of pests and diseases	114
Harvesting	114
Storage	114
HYDROPONIC CULTIVATION	114
HYDROPONICS: ADVANTAGES AND DISADVANTAGES	115
THE SYSTEM	115
GENOTYPE PERFORMANCE	116
Effect of irrigation schedule and planting method	120
Water use efficiency	122
BIBLIOGRAPHY OF LITERATURE CITED	123
Annex 1 – SOME OPUNTIA-RELATED WEBSITES	141
Annex 2 – COLOUR PLATES	143

ACKNOWLEDGEMENTS

For the preparation of his review on Ecophysiology, Park Nobel gratefully acknowledges the support of the University of California, Los Angeles - Ben Gurion Programme of Cooperation, through the generous gift of Dr Sol Leshin. Likewise, financial assistance from the Secretaría de Ciencia y Técnica de la Universidad Nacional de Cuyo is gratefully acknowledged for the research reported by Juan C. Guevara and Oscar R. Estevez, in their paper. Severino Gonzaga de Albuquerque, co-author of the chapter on “Fodder Opuntia use in the Semi-arid NE Brazil,” acknowledges his debt to his father, César Gonzaga – a grower convinced of the potential of opuntia, who passed away during the writing of the paper. Final editing, formatting and production of camera-ready copy was undertaken by Thorgeir Lawrence.