Rakesh Pathak

Clusterbean: Physiology, Genetics and Cultivation

Springer

Clusterbean: Physiology, Genetics and Cultivation

Rakesh Pathak

Clusterbean: Physiology, Genetics and Cultivation

Springer

Rakesh Pathak
Central Arid Zone Research Institute
Jodhpur, Rajasthan
India

ISBN 978-981-287-905-9 ISBN 978-981-287-907-3 (eBook)
DOI 10.1007/978-981-287-907-3

Library of Congress Control Number: 2015952529

Springer Singapore Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer Science+Business Media Singapore Pte Ltd. is part of Springer Science+Business Media (www.springer.com)

Dedicated to my parents Mrs. Urmila and Mr. R.S. Pathak, my wife Mrs. Sheela and my son Mayank

Preface

Clusterbean has become the most important export commodity in the farm sector. It is a drought tolerant leguminous crop of arid and semi-arid regions having a vast range of diverse and unique applications. It has a special place in the commercial scene due to the gum content in its seeds. India's share in the production of clusterbean seed is about 82 % and the country earns thousands of crores of rupees by exporting clusterbean products. Although the crop has attained the status of a number one agriculture export commodity in the farm sector, the productivity, production and expansion of the crop to non-traditional regions which are suitable for its cultivation require more attention. The clusterbean processing industry in India is fragmented; food safety alarms are growing in the export front because the technology of processing is not well developed. The high fluctuation in productivity and export are major concerns.

The present work provides in-depth information about the crop, its cultivation, genetic improvement, plant protection measures, management of abiotic stresses, molecular aspects, etc., and unites the value chain for the benefit of all the stakeholders of the crop, i.e. students, teachers, researchers and industrialists. This book is organized into seven chapters: Chapter 1 introduces the crop and gives the basic introduction, including prospects and constraints. Chapter 2 covers genetic improvement and variability of the crop and includes various tools and techniques used for the genetic improvement and creation of variability in the crop. Chapter 3 is dedicated to clusterbean gum and its by-products and covers the properties of gum and its application. Chapter 4 is devoted to the cultivation of the crop. Chapter 5 presents the plant protection aspect of the clusterbean. Chapter 6 addresses physiological and abiotic stress-related aspects of the crop. Chapter 7 covers the reviews of the genetic markers and the biotechnological works accomplished. The study has systematically referred to the research papers and data from industry and markets. It may prove a very useful book for industry as well as for the research community.

Rakesh Pathak

Contents

About the Author

Dr. Rakesh Pathak is a Senior Technical Officer at Central Arid Zone Research Institute, Jodhpur, Rajasthan and is a Fellow of Institution of Chemists (India). He obtained his doctoral degree on the phytochemical analysis of different cultivars of guar from the Jai Narain Vyas University, Jodhpur. Dr. Pathak has published more than 50 research papers and book chapters on molecular characterization and genetic diversity studies of several crops and trees in journals and books of national and international repute. He has molecularly characterized and submitted more than 150 novel gene sequences belonging to plant varieties/germplasm, macro-fungi, fungal pathogens and PGPRs with NCBI, USA, to address Indian biodiversity. Dr. Pathak has been regularly reviewing manuscripts as a referee for high-impact journals.

Chapter 1
Introduction

Abstract Clusterbean, tall and bushy annual herb having a deep rooted system, is a hardy and drought-resilient leguminous crop grown on sandy soils of arid and semi-arid regions. The Indian arid zone characterized by deficient moisture and nutrient, and high sunlight provides optimum agro-climatic conditions for the successful cultivation of clusterbean. It has been established as a high-valued cash crop in the arid and semi-arid regions due to its drought hardiness and multitude of usage and has occupied a special place in the commercial scene because of its gum.

1.1 Introduction

The clusterbean [*Cyamopsis tetragonoloba* (L.) Taub. (Syn. *C. psoraliodes*)], tall and bushy annual herb having a deep rooted system, is a hardy and drought-resilient leguminous crop grown on sandy soils of arid and semi-arid regions. It has been established as a high-valued cash crop in the arid and semi-arid regions due to its drought hardiness and multitude of usage and has occupied a special place in the commercial scene because of its gum. It is cultivated mainly in the rainy season and major producing states in India are Rajasthan, Haryana, Gujarat, Punjab and to a limited extent in Uttar Pradesh and Madhya Pradesh. The crop has now been a choice in southern India also. In addition to India, the crop is also grown in other parts of the world, viz. Sudan, Australia (Anonymous 1911), Brazil (Costa 1950), South Africa (Doidge 1952), Pakistan and parts of United States of America (Undersander et al. 1991).

The Indian arid zone characterized by deficient moisture and nutrient, and high sunlight provides optimum agro-climatic conditions for the successful cultivation of clusterbean, as the crop is known for high adaption towards poor and erratic rain, for its need of little surface water, abundant sunshine and low relative humidity during the cropping season (Pathak and Roy 2015). Gum obtained from clusterbean seeds is a choice of agrochemical in paper, food, mining, cosmetics,

R. Pathak, *Clusterbean: Physiology, Genetics and Cultivation*,
DOI 10.1007/978-981-287-907-3_1

textile, oil and pharmaceutical industries across the world (Hymowitz and Matlock 1963; Pawlik and Laskowski 2006; NRAA 2014). There are number of clusterbean varieties grown in India for different purposes. The major varieties are for vegetable, forage, fodder, cover crop and seed gum types. Indian cultivars and germplasms have wide variability for morphological and agronomic variability, i.e. pubescence of the plant, pattern of branching, bearing habit, shape, size and texture of the pods, seed size, colour and quantity of gum in seeds (Dabas et al. 1995).

The world's total clusterbean production has been figured around 7.5–10 Lakh tonnes every year. The production list of clusterbean is dominated by India as leading producers of the crop in the world contributing to around 75–82 % of the total production. Whereas, Pakistan follows India in the list with 10–15 % share in the world's total production. The consumption pattern of its seed is largely influenced by the demands from the petroleum industries in USA and oil fields in the Middle East. The trend of consumption has also increased in rest of the world that has led to its introduction in many countries. The world market of the crop is estimated more than 1.5 lakh tonnes annually. The main importer countries of clusterbean gum are Australia, Austria, Brazil, Canada, China, Chile, Germany, Greece, Ireland, Italy, Japan, Mexico, Portugal, Sweden, UK and USA (NRAA 2014).

Rajasthan occupies the largest area (82.1 %) under cultivation of clusterbean followed by Haryana, Gujarat and Punjab. Clusterbean was also grown regularly in Uttar Pradesh, Madhya Pradesh and Odisha during 1970s but due to closing of the processing facilities in Uttar Pradesh and Madhya Pradesh, the cultivation in these states is now insignificant. Rajasthan is the largest clusterbean producing states in the world as it dominates the Indian production scenario contributing to 70 % of the total production in India followed by Haryana (12 %) and Gujarat (11 %). In Rajasthan, Churu, Bikaner, Jaisalmer, Barmer, Nagaur, Hanumangarh, Jodhpur, Shriganganagar, Jaipur, Sirohi, Dausa, Jhunjhunu and Sikar are the major clusterbean producing districts whereas Bhiwani, Gurgaon, Mahendragarh and Rewari are the main districts of Haryana involved in the clusterbean production. In Gujarat Kuchchh, Banaskantha, Mehasana, Sabarkantha, Vadodara and Ahmedabad are the major clusterbean producing districts. After seeing great revenues with the crop during previous years by Rajasthan farmers, farmers in Ananthapur, Guntur, Karnool, Karimnagar, Nellor, Prakasam and Rangareddi districts of Andhra Pradesh have also started the cultivation of this crop for seeds in more than 1000 ha (NRAA 2014). Clusterbean has occupied its place in the Indian commodity exchanges like National Commodity Derivatives Exchange Ltd., Multi Commodity Exchange of India Ltd., etc.

The dicotyledonous seed of clusterbean from outer side to the interior consists of three major fractions, viz. the husk or hull (14–17 %), endosperm (35–42 %) and germ or embryo (43–47 %). Green, matured pod, seed and a cross section of the seed and its constituents are given in Fig. 1.1 and Table 1.1, respectively.

The clusterbean seed has rather a large endosperm unlike most of the other legumes. The dull, white-coloured and unwrinkled seeds of clusterbean are preferred for gum processing and black seeds are believed to be of low quality (Bhatia et al.

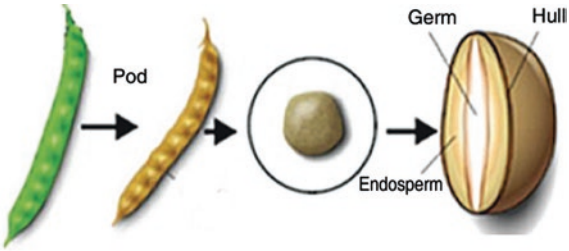

Fig. 1.1 Cross section of clusterbean seed

Table 1.1 Constituent of clusterbean seed

Part of seed	Protein (%)	Ether extract (%)	Ash (%)	Moisture (%)	Fibres (%)
Hull	5.0	0.3	4.0	10.0	36.0
Endosperm	5.0	0.6	0.6	10.0	1.5
Germ	55.3	5.2	4.6	10.0	18.0

Source Vishwakarma et al. (2009); http://www.dsir.gov.in/reports/tmreps/guar.pdf

1979; Hymowitz and Matlock 1967). But studies suggest that the black-coloured seeds may be recommended for planting or gum extraction with little loss in stand or gum yield (Bhatia et al. 1979). The galactomannan is found in the endosperm which makes up about 35 % of the dry weight of the seed, 80–90 % being pure galactomannan, having 1:2 ratio of galactose to mannose (Das and Arora 1978).

1.2 Origin

Clusterbean has been grown in India since ancient time for vegetable, manure and fodder purposes. The presence of a number of wild relatives of clusterbean in Africa suggests that it was most probably originated in Africa (Gillette 1958). It is possible that clusterbean was domesticated very early in the Africa and Arabia and made its way to Indo-Pakistan subcontinent. On the other hand, Whistler and Hymowitz (1979) mentioned that the name of cultigen in Arabic *hindia* suggests it to be an Indian origin. However, a trans-domestication concept proposed by Hymowitz (1972), illustrates that a drought-tolerant *C. senegalensis* reached to Indo-Pakistan subcontinent via Senegal to Saudi Arabia from the semi-arid and savannah zone of Sahara as waste material during Arab-Indian trade.

Hymowitz (1972) hypothesized that *C. senegalensis* the wild progenitor of clusterbean may have passes the Ethiopian route and then been carried as horse fodder to India where it was domesticated. As it is well-known that horses were the major trade between the Arabs and Indians, there is a possibility that Arabs have boarded

their ships in large quantities of fodder of clusterbean to feed their horses. The plants of *C. senegalensis* probably were cut and carried along the ship as fodder. Since the climatic conditions in the Indo-Pakistan subcontinent were favourable to *C. senegalensis*, seeds get germinated and became the basis of clusterbean. According to an another hypothesis, when the trade between middle east and India flourished during the silk route trading period, it is believed that traders brought clusterbean pods with them and wherever they went the seeds of the crop got scattered resulting in the introduction of the crop. These hypotheses on the origin of the clusterbean appear quite speculative. Except taxonomic studies, no detailed molecular or genetical studies are available in the literatures to validate the claim or prove the hypotheses.

Chavalier (1939) postulated that *C. senegalensis* probably extended up to Sindh where after domestication a few of its cultigens became cultivated in India whereas Vavilov (1951) suggested that India is the geographical centre of clusterbean variability. Dabas and Thomas (1986) indicated that the clusterbean perhaps has been domesticated in the western Rajasthan. Hymowitz (1972) believed that the African wild species *C. senegalensis* appeared to be the ancestor of West African *C. tetragonoloba*.

1.3 Taxonomic Classification

Domain: *Eukaryota*
Kingdom: *Plantae*
Subkingdom: *Viridaeplantae*
Phylum: *Magnoliophyta*
Subphylum: *Euphyllophytina*
Infraphylum: *Radiatopses*
Class: *Magnoliopsida*
Subclass: *Rosidae*
Superorder: *Fabanae*
Order: *Fabales*
Family: *Fabaceae*
Subfamily: *Paplionaceae*
Tribe: *Indigofereae*
Genus: *Cyamopsis*
Specific epithet: *tetragonoloba*—(L.)Taub.

1.4 Botany

Clusterbean belongs to the family Fabaceae or Leguminaceae and subfamily paplionaceae. It is a self-pollinated crop with $2n = 14$ chromosomes (Hymowitz and Upadhya 1963). Gillette (1958) divided the genus *Cyamopsis* in to three races,