

Genotype Alteration: The Basis for Agricultural Transformation in Tropical Drylands

A compilation of research papers of Dr N.G.P. Rao on
Sorghum Breeding and Genetics



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Preface

The three decades of 1960s, 1970s, and 1980s represent a crucial phase in India's history of agricultural transformation, from a position of food shortages and imports to one of food self sufficiency, food security, and food exports. The 1960s was the decade of initiation of the science led green revolution in India, the 1970s of its consolidation, and the 1980s of its spread (more crops and regions) and sustainability. While the new varieties of wheat and rice were the focus of the green revolution in irrigated areas, hybrid sorghum (jowar) was the focus for the green revolution in the rainfed drylands that occupy over two-thirds of the cultivated area in India. During 1970s and 80s, yield growth rates of rainfed kharif sorghum exceeded those of irrigated wheat and rice with spread of new hybrids and varieties.

Dr NGP Rao led the visionary and transformational research on sorghum as the National Coordinator of the All India Coordinated Sorghum Improvement Project from its inception in 1961 to 1978. The first commercial sorghum hybrid (CSH-1) was released by 1964, perhaps the shortest period ever for commercial hybrids in plant breeding history. Between 1965 and 1978, nine commercial sorghum hybrids (CSH 1 to CSH 9) and eight high yielding varieties (CSV 1 to CSV 8R) were released with profound impacts in the dryland areas of the States of Maharashtra, Karnataka, Telangana, Tamil Nadu, Rajasthan, Madhya Pradesh, and Uttar Pradesh, covering an area of over 8-10, mha. The new hybrids and varieties raised dryland farmer incomes substantially. They also led to the development of flourishing seed industry in India, first in the public sector and later in the private sector.

Dr NGP Rao pioneered a unique approach to the theory and practice of plant breeding to improve tropical sorghums that was based on temperate (exotic) x tropical crosses and combined both basic and applied aspects of crop genetics and agronomy. The uniqueness was with regard to three aspects. First, till 1960's, crop improvement research in India on sorghum was based on crosses between only local tropical cultivars. He introduced the idea that radical changes in cultivar improvement were feasible only through temperate (exotic) x tropical crosses. Second, was the development of a systematic breeding methodology to understand the genetics of temperate x tropical crosses of sorghum for genotype alteration for cultivar changes, and documenting it in long series of papers in Indian Journal of Genetics and Plant Breeding). Sorghum yield advancement in both tropical and temperate regions of the world now involves temperate x tropical crosses. Third, was the emphasis on simultaneously developing varieties that equalled hybrids in performance, which enabled easy access to the new improved cultivars to small and marginal farmers. This approach helped to lay the foundation of a long term programme for sorghum improvement in India which ensured that significant and stable increases in the crop's productivity are sustained across different regions and over decades. It also enabled simultaneous incorporation of valuable traits of grain quality, nutritional upgradation, multiple disease and insect resistance, and higher drought resistance and water use efficiency, in the new cultivars.

In addition to research on breeding tropical sorghums, Dr NGP Rao contributed significantly to several aspects of basic research in sorghum genetics with potential implications for breeding. These include discovery of several diverse cytoplasmic sources of sorghum and their genetic, physiological, biochemical and electron microscopy characterizations. He discovered the phenomenon of apomixis in grain sorghums, a mechanism

that could lead to fixation of heterosis and development of perpetual hybrids, and explored its potential utilization in breeding.

The Trustees of the NGP Rao Foundation considered it appropriate to capture in a consolidated Volume, the series of research papers that document Dr NGP Rao's philosophy and approach to the theory and practice of plant breeding in rainfed drylands. Such a comprehensive record of long term systematic research in plant breeding is perhaps not available for any crop other than sorghum in India or elsewhere. The Trustees expect that this compilation of visionary and systematic research over a continuum of two decades will not only be a valuable resource material for young students, teachers and scientists across the world, but will also motivate them to work towards agricultural transformation in risk prone drylands.

The contents of this volume are organized in two Parts. Part 1 presents the research on aspects directly related to sorghum breeding. Part 2 presents the basic research on apomixis and its potential utilization in sorghum breeding. Part 1 comprises published papers on sorghum breeding and related aspects in their chronological order (except the first and last 3 papers). The first paper (Presidential address to the Indian Society of Genetics and Plant Breeding in 1981) sets the stage by presenting the broad philosophy and approaches adapted by Dr NGP Rao and his colleagues for breeding superior hybrids and varieties of tropical sorghums. Papers 2 to 17 document the research in initial phases, leading towards the release of the first two high yielding commercial hybrids CSH-1 and CSH-2 and the variety Swarna, the studies on the performance and stability of the new hybrids, and the national recognitions that followed their release. The 18th paper is the first in the systematic series of papers, titled '*Genetic analysis of some exotic x Indian crosses in sorghum*' - I to XXXIX, that began in 1970, and continued to 1986. The series describes the genetics of temperate x tropical crosses in sorghum involving the nature of gene action in yield heterosis, gene x environment interactions, disease and insect resistance, character associations, selection criteria and methods, crop ideotypes, testing procedures, adaptability analyses etc. This series of papers appears in sequences of clusters of 3 to 5 or 6 (from papers 18 to 98) in different years. The clusters are interspersed by papers that furnish related information, or are periodic conference papers that summarize the status on different aspects of breeding up to that time and point the way forward for the next few years. The last 2 papers provide future perspectives respectively of how plant manipulations via breeding can address food security and production risk concerns in the context of climate change, and such manipulations can be synergistically combined with environmental modifications (with land, soil and water technologies) for greater productivity and stability within dryland agriculture systems. The latter was the Second BP Pal Memorial Lecture at Indian Society of Genetics and Plant Breeding in 1991, (a decade after the first paper above).

Trustees

Contents

Part 1: Sorghum Breeding

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