Studies in History and Philosophy of Biological and Biomedical Sciences 50 (2015) 41–50

Contents lists available at ScienceDirect

Studies in History and Philosophy of Biological and Biomedical Sciences

journal homepage: www.elsevier.com/locate/shpsc

Wide adaptation of Green Revolution wheat: International roots and the Indian context of a new plant breeding ideal, 1960–1970

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ARTICLE INFO

Article history:
Available online 3 February 2015

Keywords:
Green Revolution
India
Norman E. Borlaug
Plant breeding
Rainfed agriculture
Rockefeller Foundation

ABSTRACT

Indian wheat cultivation changed radically in the 1960s due to new technologies and policy reforms introduced during the Green Revolution, and farmers' adoption of 'packages' of modern seeds, fertilizer, and irrigation. Just prior to the Green Revolution, Indian scientists adopted a new plant breeding philosophy—that varieties should have as wide an adaptation as possible, meaning high and stable yields across different environments. But scientists also argued that wide adaptation could be achieved by selecting only plants that did well in high fertility and irrigated environments. Scientists claimed that widely adapted varieties still produce high yields in marginal areas. Many people have criticized the Green Revolution for its unequal spread of benefits, but none of these critiques address wide adaptation—the core tenant held by Indian agricultural scientists to justify their focus on highly productive land while ignoring marginal or rainfed agriculture. This paper also describes Norman Borlaug's and the Rockefeller Foundation's research program in wide adaptation, Borlaug's involvement in the Indian wheat program, and internal debates about wide adaptation and selection under ideal conditions among Indian scientists. It argues that scientists leveraged the concept of wide adaptation to justify a particular regime of research focused on high production agriculture.

When citing this paper, please use the full journal title *Studies in History and Philosophy of Biological and Biomedical Sciences*

1. Introduction

Over the past 45 years, many scholars and activists have criticized the impacts of Green Revolution agriculture in India. Some of these critiques focused on the unequal socio-economic spread of technologies that favored the larger, irrigated farms of the Punjab region over smaller, rainfed farms (Anderson, Brass, Levy, & Morrison, 1982; Cleaver, 1972; Frankel, 1971; Griffin, 1974; Ladejinsky, 1969). Fewer of these critiques identified that the varieties of wheat and rice released in the mid-1960s[1] were not adapted to rainfed, low fertility agro-climatic conditions that marginal farmers[2] typically face (Farmer, 1979; Lewontin, 1983; Oasa, 1981; Saha, 2012; Sen, 1974). But few of these critiques directly addressed *why*, in the mid-1960s, Indian agricultural scientists decided to focus the national system of wheat research on high fertility and irrigated conditions. Understanding why wide adaptation became the dominant framework in Indian plant breeding is critical to further cracking open the "black box" around wide adaptation that is still extremely influential to modern wheat breeding programs for developing countries.

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[1] Varieties developed through Rockefeller Foundation-sponsored international agricultural research programs.

[2] Farmers in marginal environments. I use Cleveland's definition of marginal farms or environments as "crop growing environments that have relatively high levels of stress for yield production (e.g., drought), …that often have relatively high levels of variability in these stress factors through space and time (e.g., rainfall with high spatial, intraannual, and interannual variation), and where farmers do not apply many external inputs (e.g., irrigation water)" (2001, pp. 264).

http://dx.doi.org/10.1016/j.shpsc.2015.01.004

Just prior to the Green Revolution, Indian wheat scientists adopted a new plant breeding philosophy that emphasized the wide adaptation of crop varieties.[3] Scientists defined this ideal as a variety that produces high and stable yields in varying environments, also called broad adaptation or phenotypic stability (Finlay & Wilkinson, 1963). Up to the mid-1960s, cereal breeders viewed wide adaptation with skepticism, assuming that varieties should be bred in the area they are to be grown. But in the late 1950s, Norman E. Borlaug of the Rockefeller Foundation (RF) in Mexico discovered wheat varieties with what he called "surprisingly broad adaptation" due to their photoperiod insensitivity (Borlaug, 1968, pp. 8). Borlaug's successful wheat program introduced the radical idea of purposeful wide adaptation into mainstream agricultural science. Simultaneously, Borlaug consulted on Indian wheat research, and is credited with introducing his new varieties of wheat and the concept of wide adaptation to India.

In the mid-1960s the Indian wheat program, under RF influence, underwent three significant changes. It became centralized (Raina, 2009; Saha, 2012), varieties were tested under soil fertility rates roughly twenty-five times higher than average soil fertility rates in India,[4] and varieties were judged based on their average performance over several locations in multi-state agro-climatic zones.[5] Indian and RF wheat scientists argued that by selecting varieties under high fertility and irrigated conditions, they could create high yielding, widely adapted varieties. They claimed that widely adapted varieties would still produce high yields in marginal environments, ostensibly to placate India's economic planners who favored a socialist agricultural system (Saha, 2012). In reality, the Indian wheat program focused on the ideal agro-climatic conditions of northwest India.

This article focuses on why wheat scientists in India and at the RF argued for, and in some cases against, centralization of research, wide adaptation, and selection[6] in favorable (high fertility, controlled irrigation) environments. Both qualitative and quantitative data suggest that widely adapted varieties from Mexico were in fact adapted to high fertility, irrigated conditions but not to low fertility, rainfed conditions. Despite this, scientists from India and the RF used the concept of wide adaptation to justify changes in the Indian wheat program that have led to a problematic, systemic bias against marginal agriculture.

The concept of wide adaptation underlies past and present research agendas, technologies, and policies in India, yet has seldom been scrutinized through a historical lens. Historians of biology can contribute to recent literature on controversial agricultural science by exploring the historical roots of agricultural technologies and ideologies.[7] Using historical sources such as conference proceedings, correspondence, and crop data from India, this paper highlights the history of the controversy over wide adaptation in order to understand how it became a doctrine of Indian wheat science.

[3] Adaptation in this case refers to the performance of a plant in a given environment or condition rather than a process (Cooper & Byth, 1996).

[4] See §2.1.

[5] *Proceedings of the Seventh All India Wheat Research Workers' Workshop*. (1968). Folder 555, Box 85, Series 4, RG 6.7, Field Offices, New Delhi, FA396. Rockefeller Foundation records, Rockefeller Archive Center.

[6] In the context of plant breeding, "selection" is the process of choosing a plant from a segregating or non-segregating test population in order to breed or multiply that variety.

[7] See Sumberg, J. & Thompson, J. (Eds.) (2012). *Contested Agronomy: Agricultural Research in a Changing World*. London: Routledge.

1.1. Reorganizing the Indian wheat program: centralization and a northwest bias

A major reorganization of Indian agricultural science occurred in 1965, building off of both prior institutional innovations and RF involvement. Although Indian wheat breeding programs existed from the early 1900s, efforts were decentralized and resulted in marginal gains in wheat yield. In 1934 Indian scientists decided to coordinate state efforts, and "that a collaborative beginning for breeding rust-resistant varieties of hill wheats should be undertaken at Simla… placed under the charge of Dr. B.P. Pal."[8] Benjamin Peary Pal, a prominent wheat breeder, advocated coordinated wheat disease research in India throughout the 1930s, 40s, and 50s.[9] In 1952 the Indian Council of Agricultural Research (ICAR) approved Pal's coordinated scheme to control rust, a viral pathogen that affects wheat.[10] Thus, the idea of a coordinated agricultural program, which would soon become a central feature of Indian agricultural research, preceded RF involvement.

In the 1950s, Indian agricultural policy-makers and prominent scientists began a large-scale reorganization of crop research programs and agricultural education. The Indian government invited two RF scientists, Edwin J. Wellhausen and Ulysses J. Grant,[11] to review Indian agriculture in 1954, concentrating on maize research. The RF scientists noted that a major impediment to progress in maize breeding was the lack of coordination between decentralized research centers[12]; this was later confirmed by an agricultural review team consisting of both RF and Indian scientists.[13]

In 1956, the Indian government invited the RF to coordinate maize, millet, and sorghum research. The Government of India and RF signed a memorandum of understanding and in 1957 started the Coordinated Maize Breeding Scheme under RF scientists Ralph W. Cummings and Grant. A subcommittee of ICAR, led by Pal, "recommended the division of the country into… four zones for purposes of maize breeding work."[14] This novel idea for coordinated breeding according to broad agro-climatic zones ironically led to a centralized research program.

ICAR started an informal coordinated wheat program in 1961 "modeled on the coordinated maize program,"[15] and put scientists at the Indian Agricultural Research Institute (IARI) in charge. ICAR then invited Borlaug to consult on wheat research in India in 1963. Borlaug recruited R. Glenn Anderson, a Canadian wheat scientist, to join the Indian team in late 1964 and spearhead the new "unified

[8] Kohli, S. P. (1968). Wheat Varieties in India. *ICAR Technical Bulletin No. 18*, pp. 20. Folder 544, Box 84, Series 4, RG 6.7, Field Offices, New Delhi, FA396. Rockefeller Foundation records, Rockefeller Archive Center.

[9] Indian Council of Agricultural Research. (1952). *Proceedings of the Meeting of the Advisory Board from the 3rd to the 5th January 1951*. New Delhi: ICAR, pp. 105–6. Indian Agricultural Research Institute archives, New Delhi.

[10] Indian Council of Agricultural Research. (1954). *Annual Report 1951–52*. New Delhi: ICAR, pp. 18. Indian Agricultural Research Institute archives, New Delhi.

[11] At that time, Wellhausen directed the RF Mexican Agricultural Program, and Grant led the RF Columbian Agricultural Program's corn improvement program.

[12] Grant, U. J., & Wellhausen, E. J. (1955). *A study of corn breeding and production in India*. Folder 324, Box 46, Series 4, RG 6.7, Field Offices, New Delhi, FA396. Rockefeller Foundation records, Rockefeller Archive Center.

[13] Parker, M. W., Cheesman, E. E., Lovvorn, R. L., Maheshwari, P., Ramiah, K., Ross, O. B., Sahai, L. (1963, December 13). *First draft of "Report of the agricultural research review team."* Folder 552, Box 58, Series 464D, RG 1.2, Projects, FA387. Rockefeller Foundation records, Rockefeller Archive Center.

[14] Indian Council of Agricultural Research. (1957). *Report of the sub-committee of the botany committee of ICAR*. Folder 258, Box 39, Series 4, RG 6.7, Field Offices, New Delhi, FA396. Rockefeller Foundation records, Rockefeller Archive Center.

[15] Anderson, R. G. (1970). *Wheat position paper*. Folder 153, Box 27, Series 2, RG 6.7, Field Offices, New Delhi, FA396. Rockefeller Foundation records, Rockefeller Archive Center.