Forging Research and Development Partnerships with Private Sector at ICRISAT-Sorghum as a Case Study

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ICRISAT – its mission and strategy

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), established in 1972 with its headquarters at Patancheru, Andhra Pradesh, India, is a non-profit, non-political, international research organization for science-based agricultural development. It belongs to the Alliance of Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR). ICRISAT conducts research on its mandate crops – sorghum, pearl millet, chickpea, pigeonpea and groundnut – which support the livelihoods of the poorest of the poor in the Semi-Arid Tropics (SAT). The mission of ICRISAT is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT pursues an integrated genetic and natural resource management (IGNRM) strategy to improve the livelihoods of the poor in the semi-arid crop-livestock-tree production systems. The strategic focus in the SAT is to attain impact while maintaining a global level of scientific excellence in agricultural research.

Public-private partnership research – the way forward

Private sector (PS) investment in agribusiness – to provide quality seed, food, and feed and enhanced livelihoods – has increased recently in developing countries. This is in response to the market-friendly government policies in India and many other developing countries. It is now widely recognized that, in the next decade, international efforts to apply science to the problems of the world's poorest people will be characterized by the joint efforts of both public and the PS by exploiting complementarities and synergies between them (Dar 2001). Research-for-development institutes, therefore, need to forge partnerships with the PS to complement research efforts to transfer their technologies as well as to elicit research-funding support and feedback on the adoption and impact of the technologies.

Public-private partnership at ICRISAT

ICRISAT has taken a proactive approach to develop partnerships with PS seed companies to jointly deal with the main constraints to agribusiness development through the identification of priorities and joint investments in key research areas. The partnerships/arrangements are developed considering the synergies and complementary expertise between ICRISAT and the PS. In this paper, we describe briefly the objectives, nature and mode of ICRISAT's partnership arrangements with the PS in the areas of hybrid parents and sweet sorghum improvement research and development, and discuss the expected impacts of these partnerships on the livelihoods of farmers and consumers.

A. Hybrid parents development

ICRISAT's research in the development of sorghum hybrid parents has contributed several parental lines that are international public goods (IPGs) and freely accessible to both public and PS research organizations. The business-oriented PS organizations, and the farmers they serve, have derived immense economic benefits from ICRISAT-generated research products (breeding materials, hybrid parental lines and research information) in sorghum. Over the years, the PS in India has emerged as a major channel for delivering ICRISAT's seed-based technologies to poor farmers in India, and other SAT of the world.

Objectives

The primary objective of the ICRISAT-PS partnership has been to enhance the pace of impact of ICRISAT-developed research products where both parties play complementary roles in the areas of their expertise to generate the synergy for more effective research and development. Thus, ICRISAT concentrates on strategic research emphasizing germplasm evaluation and its genetic improvement, including the development of parental lines of potential hybrids; while the private sector emphasizes the development and testing of hybrids, seed production and marketing of hybrids, continued assessment of farmers and consumer preferences, and changing market demands. In recent years, one more dimension of this partnership has emerged that relates to resource mobilization from the PS to provide partial funding support to ICRISAT's hybrid parents' research.

Evolution, nature and mode of partnerships

The partnership between ICRISAT and PS seed companies has evolved over time. In the early years, ICRISAT played a nurturing role to the fledgling PS seed industry and provided the breeding material, often through informal networks. However, ICRISAT scientists realized the significant research and developmental capabilities of the PS, particularly in the larger companies and soon recognized that the Institute's traditional relationship with public sector breeding programs, though important, was no longer the sole route to farm-level adoption of the hybrids developed based on ICRISAT-bred research products. This realization was all the more pertinent following the succession of funding shocks in ICRISAT and other CGIAR centers accompanied by increased scrutiny of the value and impact of international agricultural research efforts (Reddy et al. 2001).

All these considerations led to conceptualization and initiation of Sorghum and Pearl Millet Hybrid Parents Research Consortia during 2000 at ICRISAT, the first of its kind in the entire CGIAR system (Reddy et al. 2001). This partnership envisaged development of hybrid parents, hybrid seed production and dissemination to the clientele and partial funding support to ICRISAT's hybrid parents research with an explicit understanding that the products from this research will still remain in the public domain and ICRISAT will retain the exclusive rights on its research products. This consortium was later restructured in 2004 with expanded participation of PS companies and higher levels of funding support from each company. In the new structure, the research products are in the public domain with free access by both the public and private sector. The non-member PS companies have access to parental lines of released hybrids, three years later.

Results and impacts

Channelizing research products to end-users. ICRISAT's partnerships with the PS and public sector had significant impact on developing and disseminating large sets of hybrid parents. For example, ICRISAT supplied 93,985 sorghum seed samples of improved hybrid parents to the public and the PS in India as well as other countries between 1986–2000, and the PS received 41% of these samples. After the formation of the consortium, ie, from 2001 to 2004, ICRISAT supplied a total of 25,479 seed samples of improved breeding lines to both public and PS scientists in India, of which the PS share was 56%. Using the ICRISAT-bred materials, seed companies developed and marketed the most promising hybrids and derived immense economic benefits in India (and other countries in Asia).

ICRISAT regularly organizes field days to enable partners to observe and select appropriate breeding materials. Twenty-eight public sector scientists from 16 organizations and 29 PS scientists representing 16 companies in sorghum participated in the Scientists' Field Day organized at ICRISAT, Patancheru, during 2000. A total of 4678 sorghum seed samples belonging to more than 1600 distinct lines were supplied to 28 scientists (15 from public and 13 from PS organizations) based on their selection during the field days. Nearly 55% of these were provided to the PS (Gowda et al. 2003). Similarly, 22 public sector scientists and 16 PS scientists participated and selected several lines in the Sorghum Scientists' Field Days at ICRISAT-Patancheru during 22–23 September 2004. Based on the seed requests received after the field day, a total of 1209 seed samples were supplied to seven scientists in public sector organizations and 535 seed samples to nine scientists of PS seed companies (Table 1). In terms of distinct sorghum hybrid parents, 171 female lines and 339 restorers were supplied to the public sector and 102 female lines and 97 restorers to the PS. Thus, the public sector received 72% and the PS 28% of the hybrid parents supplied. The number of distinct hybrid parents supplied to the public and PS together are 200 female lines and 398 restorers.

Common platform to assess promising hybrids. PS seed companies often develop many promising hybrids, but they are permitted to contribute only 1–2 hybrids to the All India Coordinated Trials for multilocational evaluation. The consortium partners requested ICRISAT to coordinate a multi-locational trial of hybrids from consortium members, thus providing a common platform for the evaluation of promising hybrids.

Table 1. Number of improved distinct lines and sorghum seed samples supplied to public and PS scientists in India upon specific requests after 2000 and 2004 sorghum Scientists' Field Days.

	Scientists		No. of distinct lines selected		No. of seed samples supplied	
Sector	2000	2004	2000	2004	2000	2004
Public	15	07	720	510	2102	1209
Private	13	09	880	199	2576	535
Total	**28**	**16**	**1600**	**709**	**4678**	**1744**

Reduced time lag in developing hybrids. ICRISAT develops hybrid parents, while the PS makes hybrid combinations from selected hybrid parents. Promising hybrids identified from preliminary in-house testing of large number of hybrids are evaluated in ICRISAT-coordinated multi-location trials to identify hybrids suitable for marketing. These complementary roles of ICRISAT and the PS help reduce time required for developing and marketing new hybrids by about three to four years.

Cultivar adoption. The ICRISAT-PS partnership has greatly contributed to the development and marketing of improved hybrids and varieties in Asia. In India, more than four million ha of rainy season sorghum (80% of the total rainy season sorghum area) and one million ha of the summer season sorghum are planted with about 70 PS-based hybrids, of which 54 are based on ICRISAT-derived parental lines or their derivatives. An ICRISAT-PS partnership hybrid, JKSH 22, known for its high grain yield potential, large grain and earliness (5–10 days compared to the most popular hybrid CSH 9) showed remarkable adoption covering 210,000 ha in 2002 (about 0.5% of the total rainy season sorghum area) (Reddy et al. 2004). The adoption of another ICRISAT-PS partnership high yield potential hybrid, VJH 540, increased from 650 ha in 1997 to 1,42,000 ha in 2003 (Figure 1) in rainy season in major sorghum growing areas in India, as evidenced from the increased seed sales of this hybrid from 6.5 t in 1997 to 1420 t in 2003 (personal communication from Dr Yogeshwara Rao, Executive Director, Vikki's Agro-Tech Ltd. Hyderabad).

These are only illustrative examples of the power of partnership to exploit the complementary expertise between ICRISAT and the PS to develop and deliver desired products to the farming community. Apart from these, several other private sector hybrids, such as MLSH 296, GK 4009 and GK 4013, are widely adopted in India. High rate of adoption of ICRISAT-based hybrids is due to large grain, higher grain and fodder productivity. These hybrids have made substantial contributions to enhance cultivar diversity, productivity, yield stability, and also improved the livelihoods of poor farmers in the dry areas (Gowda et al. 2003).

Benefits from seed production. Seed production regimes were developed and started in mid-1960s by the public sector organizations when public sector-bred hybrids were released initially in early 1960s in India. The popularity of PS hybrids, most of which are based on ICRISAT-developed parental lines or their derivatives has further expanded seed production activity in several villages in Andhra Pradesh and Karnataka states of India. It is estimated that on an average, hybrid seed production fetches US$630 ha^{-1}, about three times the income from commercial crop. Between 1994 and 2002, for example, seed production of JKSH 22 (an ICRISAT-PS partnership hybrid) earned farmers, on an average, US$0.3 million

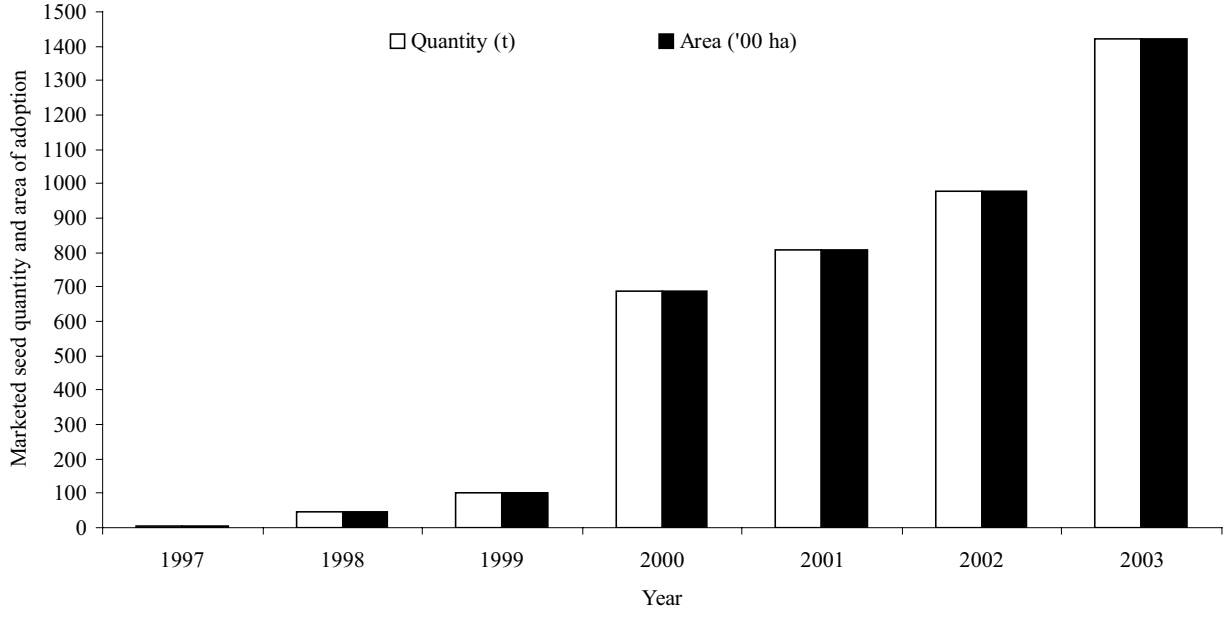

Figure 1. The area of adoption and seed sales of VJH 540, an ICRISAT-PS partnership hybrid in India.

per year in Andhra Pradesh and Karnataka, and US$2.7 million per year from commercial cultivation of JKSH 22 in Maharashtra and other sorghum growing areas in India (Reddy et al. 2004). Several seed villages in Andhra Pradesh and Karnataka became prosperous by taking large scale hybrid seed production (C Ramakrishna, JK Seeds, Hyderabad, personal communication). In the last three years, a total of 29,800 t of certified seed of ICRISAT-PS sorghum hybrids was produced contributing about 65% to the total hybrid seed production (Reddy et al. 2004), which gave a total income of US$18.8 million to seed growers in India, and has led to improved livelihoods as a result of higher income accrued from hybrid seed production.

Resource mobilization. During the first phase of the consortium (2000–2003), ICRISAT generated US$0.2 million for sorghum hybrid parents research. As of May 2005, 17 PS seed companies (13 primary and 4 promotional members) have enrolled as members in the revised Sorghum Hybrid Parents Research Consortium for a five-year period. Through this consortium, ICRISAT expects to generate funds of US$0.75 million over a five-year period. The funds generated will augment the core funds to support sorghum improvement research at ICRISAT for developing elite sorghum hybrid parents to serve the public and private sectors. This resource mobilization is particularly significant at the crucial time of diminishing core funding to crop improvement research at ICRISAT.

Feedback on research and cultivar adoption. Scientists' Field Days and meetings provided opportunity to elicit feedback on the utility of ICRISAT-bred hybrid parents, more specifically the number of hybrids developed and marketed, extent of farm-level adoption of hybrids, and constraints for their adoption. Feedback received suggested that the development of both grain and forage type A-/B-lines and diversification of CMS-base of A-/B-lines and molecular-assisted breeding for resistance to drought, grain mold and shoot fly are important. These feedbacks are in agreement with those reported by Umakanth and Seetharama (2003) through an extensive survey seeking scientists from All India Coordinated Sorghum Improvement Project (AICSIP) centers and randomly selected PS seed companies to score on the economic importance of rainy season sorghum production constraints. The feedbacks from PS and the national agricultural research systems (NARS) have helped set priorities (such as farmer or trade or industry preferences) for future global sorghum improvement research at ICRISAT.

B. Sweet sorghums for ethanol production

With the Government of India's policy to blend petrol and diesel with 5% ethanol (and likely to increase this proportion to 10% gradually), the requirement of ethanol in India is around 5000 million L. The current ethanol production from sugarcane molasses and other sources is estimated to be 2000 million L, leaving a deficit of 3000 million L, which can be readily made good by promoting the use of sweet sorghums in ethanol production

Objectives

ICRISAT is following a two-pronged strategy: (1) Development of sweet sorghum cultivars through partnership and (2) facilitation of the ethanol production technology using newly developed sweet sorghum cultivars.

Mode of partnerships

In collaboration with public sector scientists in India, sweet sorghum cultivars will be developed. Through memorandum of agreement and business work plans, the ethanol production technology will be transferred to the private sector distilleries under the Agri-Business Incubator (ABI) at ICRISAT.

Results and impacts

ICRISAT renewed a program for the identification and development of sweet-stalk and high-biomass sorghum hybrid parents and varieties in 2002. Promising lines such as ICSB 631 and ICSB 264 among the seed parents; and Seredo, ICSR 93034, S 35, ICSV 700, ICSV 93046, E 36-1, NTJ 2 and Entry 64 DTN among the varieties/male parents were identified for their high stalk sugar content at ICRISAT, Patancheru. The sugar percentage in these seed parents and varieties ranged from 16.8 to 21.6%. Four of these lines, S 35, ICSV 700, ICSR 93034 and Entry 64 DTN, are being evaluated in AICSIP centers and two of these (ICSV 700 and ICSR 93034) with high stalk-sugar content and juice yield (kL ha^{-1}) have been promoted for advanced testing.

A sweet sorghum hybrid, NSSH 104, developed from ICSA 38 [an ICRISAT-bred male-sterile (seed) parent] and SSV 84 [a male parent bred in Indian program] is being recommended for release for commercial cultivation. The Indian national sorghum program,

through extensive testing, released a sweet-stalk sorghum variety SSV 84 in 1992/93 for general cultivation. Several promising sweet-stalk hybrids developed at ICRISAT, Patancheru, have been contributed for multi-location testing.

ICRISAT has signed a Memorandum of Agreement (MOA) with Vasanthadada Sugar Institute (VSI), Pune, for identification/development of improved sweet sorghum varieties, characterizing the juice, and ethanol quality and quantity. The ABI has signed another MOA with Rusni Distilleries Private Limited of Hyderabad, to incubate the ethanol production technology using these sweet-stalk sorghum lines.

ICRISAT is hopeful that private seed companies in India would complement the efforts of the national program in the development of location-specific hybrids with sugar-rich high stalk yield (using hybrid parents developed in ICRISAT and the national program) to meet the expected increased demand for raw material for ethanol production in the years to come.

Acknowledgments. Contributions of several scientists, including HC Sharma, RP Thakur, LR House (late), JW Stenhouse, SZ Mukuru, KV Ramaiah, MJ Vasudeva Rao, BL Agarwal, DS Murty, Bholanath Verma, H Doggett, R Bandyopadhyay, KF Nwanze, SL Taneja, K Leuschner, R, Jambunathan, SD Singh, LK Mughogho, and Suresh Pande in the development of sorghum hybrid parents are duly acknowledged.

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Prospects of Breeding for Micronutrients and β-Carotene-Dense Sorghums

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Introduction

Micronutrient malnutrition, primarily the result of diets poor in bio-available vitamins and minerals, causes blindness and anemia (even death) in more than half of the world's population, especially among women and pre-school children (Underwood 2000). Two micronutrients, iron (Fe) and zinc (Zn) and pro-vitamin A (β-carotene) are recognized by the World Health Organization (WHO) of the United Nations as limiting. Deficiency for Fe, Zn and β-carotene is highest in South and Southeast Asia and sub-Saharan Africa (SSA). These are also the regions [typified as semi-arid tropics (SAT)] where sorghum (*Sorghum bicolor*) is cultivated and consumed as a staple food by millions of people. The introduction of crop varieties selected and/or bred for increased Fe, Zn and pro-vitamin A contents through plant breeding approach will complement the existing approaches (such as fortified foods and food supplementation while processing) to combat micronutrient deficiency. The plant breeding approach would avoid dependency on behavioral changes in farmers or consumers unlike other programs.

In this paper, we report and discuss the results of pre-breeding research carried out at ICRISAT, Patancheru, as a part of the short-term strategy of HarvestPlus, [the Consultative Group on International Agricultural Research's (CGIAR's) challenge program seeking to reduce micronutrient malnutrition by developing micronutrient-rich crop varieties in high-yielding background] and their implications on the prospects of breeding for micronutrients and ß-carotene-dense sorghums.