Public-private partnership and impact of ICRISAT's pearl millet hybrid parents research

RP Mula*, KN Rai, VN Kulkarni and **AK Singh**

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

*Corresponding author: r.mula@cgiar.org

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Introduction

Genetic improvement of pearl millet (*Pennisetum glaucum*) at the International Crops Research for the Semi-Arid Tropics (ICRISAT) initially had greater emphasis on population improvement and development of open-pollinated varieties (OPVs) compared to hybrids and hybrid parents development. By late 1990s, a significant decline in OPV development occurred in the Institute's research program in the Asia region (Rai et al. 2006), where India accounts for more than 90% of total pearl millet area (10.5 million ha) in the region. Greater emphasis was placed on hybrid parents development to align the research focus of the institute with the regional priority of the national agricultural research systems (NARS) and the rapidly expanding private seed sector. A stronger interaction with the Indian NARS, largely under the umbrella of ICAR (Indian Council of Agricultural Research)-ICRISAT Research Partnership was formulated. The interaction with the private seed sector remained informal and passive, although it continued to derive immense economic benefits from ICRISAT's research products. With a view primarily to engage the private sector in more active partnership to hasten the pace and scale of impact, and to generate research fund to provide partial support to pearl millet improvement research at ICRISAT, a consortium model was conceptualized as the most appropriate among various partnership models, which became effective in 2000 (Gowda et al. 2003). This paper presents the evolution of this consortium, and examines the impact of ICRISAT's research in terms of strengthening the research programs of ICRISAT, NARS and the private sector, on-farm hybrid cultivar diversity, and increasing participation of the private sector in the documentation of achievements of research and development activities.

Consortium membership

The two key elements of the consortium guidelines developed in 2000 were: (1) the consortium-funded research will address the core research agenda of the Institute; and (2) all information and breeding products of this research will remain in the public domain as international public goods. As per consortium guidelines during Phase 1 (2000–03), ICRISAT-bred material continued to be freely available to all the public and private sector organizations worldwide. Since it was voluntary for the private sector to join the consortium, only nine seed companies became consortium members in 2000. This membership grew to 15 in 2001, but it remained static till 2003 (Fig. 1) with several large corporate size seed companies still not joining the consortium, although the annual contribution from a company was only US$5000. Thus, the consortium guidelines developed in 2000 were revised in 2004 with two significant changes. First, the seed companies who are not members of the consortium can have access, on nominal charge basis, only to those parental lines which are formally released by the Central/State Variety Research Committee; they will not have access to breeding materials and intermediate products (ie, parental lines designated or at the advanced stages of development). Second, consortium membership will be of two types: (1) primary members, who contribute US$10,000 (equated to Rs 500,000) annually, will have access to all classes of breeding materials and parental lines (up to 100 lines per year free); and (2) promotional members, who contribute US$5000 (equated to Rs 250,000) annually, will have access to only the designated and released parental lines (up to 50 lines per year free). This led to the increasing participation of seed companies in the consortium, with 24 seed companies joining the consortium in 2004 that increased to 34 seed companies in 2006, with 25 of these being the primary members and 9 being the promotional members. This generated a total revenue of US$300,000 in 2006. It is significant that a Foundation joined this consortium in 2005, and a state seed corporation joined in 2006.

Dissemination of breeding materials and parental lines

ICRISAT constitutes numerous trait-based trials and nurseries of its mandate crops and supplies it to NARS around the world for evaluation and utilization in the recipients' research programs. These trials and nurseries are supplied based on the agreed collaborative work plans or based on specific requests from public-sector institutions and the consortium seed companies. ICRISAT organizes Scientists' Field Days every year or alternate year to enable partners visit the field experiments and breeding nurseries, and select the breeding materials, including parental lines of potential hybrids, of their interest. During the Pearl Millet Scientists' Field Day in 2000, 38 scientists from the seed companies (about three times as many as those from the NARS) participated in this Field Day and selected 1969 breeding lines (including sister lines) and parental lines of potential hybrids, which was about two times as many as the

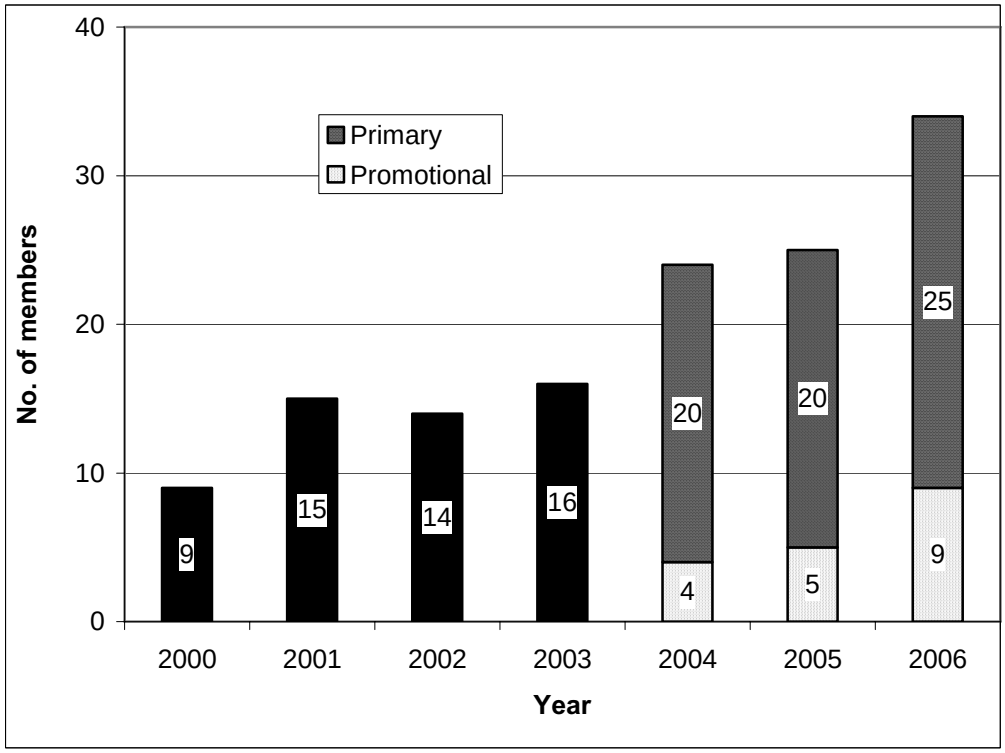

Figure 1. Growth in the membership of Pearl Millet Hybrids Parents Research Consortium partnering with ICRISAT.

Table 1. Number of pearl millet breeding lines selected during the Scientists' Field Day at ICRISAT, Patancheru, India and seed samples supplied.

Description	Field Day year	Public	Private	Total
Number of participants	2000	14	38	52
	2004	18	24	42
	2006	18	42	60
Number of lines selected	2000	1014	1969	2106
	2004	883	831	1312
	2006	1031	1348	1804
Number of samples supplied	2000	2110	9999	12009
	2004	1756	1562	3318
	2006	2162	5348	7510

number of lines selected by the NARS scientists (Table 1). The number of seed samples requested and supplied to the private seed companies was about five times as much as those supplied to NARS. In 2004, there was a drastic reduction in the number of lines requested and the number of seed samples supplied. However, after the relaxation of the charge system for seed supplies (as per the revised consortium guidelines), the private sector participation increased in 2006, and so did the number of lines selected by them (30% more than the NARS) and the number of seed samples supplied (147% more than the NARS). This is supportive of the findings of an earlier study, which showed that the private sector has emerged as a dominant player, seeking access to the ICRISAT-bred materials in pearl millet as well as sorghum (*Sorghum bicolor*) (Pray et al. 2001). The private sector has a major share in the seed market in India, estimated at 60–70% (Shiva and Crompton 1998), and it would be no different for pearl millet. Under the consortium partnership, ICRISAT not only simply supplies pearl millet lines requested by the private seed companies (and also by the NARS), but also provides information on the pedigree, flowering time and downy mildew resistance to enable them make rational selection based on their requirements for genetic diversity, maturity and downy mildew resistance to specific pathotype(s).

Impact assessment survey

The survey was initiated to ascertain the impact of ICRISAT-derived breeding materials on the consortium partners. The primary information on the subject discussed below was obtained through a survey questionnaire, which was jointly prepared by scientists from ICRISAT and the consortium seed companies. Of the 34 consortium members, 25 provided information on the number of hybrids marketed, with a few providing sufficient information on the number of hybrids developed and marketed, extent of utilization of ICRISAT-bred pearl millet germplasm, and economic returns to farmers undertaking hybrid seed production.

Utilization of ICRISAT-bred materials

Twenty-eight of the 34 consortium seed companies responded to a survey on the number of hybrids they marketed in 2006. Of these, three companies had not marketed any hybrids yet, while the other 25 marketed 1–7 hybrids each (Table 2). There were nine seed companies that marketed more than 4 hybrids each. Thus, there were a total of 82 hybrids that were marketed by these companies. It is assumed that other consortium seed companies who did not respond, and also those who are not members of the consortium but have research base (there are at least five) marketed at least another 10 hybrids. Thus in total, 92 hybrids that were marketed in 2006. How different or similar are the parental lines of these hybrids is a subject worthy of further investigation. Of the 25 companies who provided data on the number of hybrids marketed, only six revealed the extent of ICRISAT-bred parental lines used in developing 18 hybrids that they had marketed. All of these had at least one parent that had been bred at ICRISAT, or had ICRISAT-bred materials involved in the parentage of the proprietary parental lines. Fourteen hybrids (ie, 78% of the total) were based on ICRISAT-bred A-lines, while another 3 had 25–50% ICRISAT-bred materials in the parentage of their proprietary A-lines. By extrapolation, it would appear that about 72 hybrids out of 92 marketed in 2006 could be based on ICRISAT-bred A-lines and another 15 might have 25–50% ICRISAT-bred materials in the parentage of proprietary A-lines. The extent of adoption of all these hybrids, and the economic returns from them is a subject matter of future studies.

A case study of two hybrids was done to show their adoption over time, and the successes specific to these companies. Both hybrids are based on ICRISAT-bred A-lines or on their sub-selections developed by the seed

Table 2. Number of pearl millet hybrids marketed by consortium seed companies in India in 2006.

Names of the companies (Coded)	No. of hybrids per company	Total no. of hybrids
C3, C14, C38 and C40	1	4
C1, C7, C10, C18 and C27	2	10
C2, C9, C12, C19, C25, C28 and C39	3	21
C6, C15 and C41	4	12
C22, C31 and C36	5	15
C13	6	6
C21 and C29	7	14
Total (25 companies)	–	82

companies by exploiting the residual variability. Since almost all the ICRISAT-bred A/B lines have largely been developed by pedigree-bulk breeding, a small degree of within-line variability does exist, as has been found in a few selection experiments for flowering time and downy mildew resistance. The hybrid JKBH 26, developed by JK Agri Genetics, is based on an A-line on which no other organization from the private sector or from the Indian national program has any hybrid in the market. This hybrid has been under cultivation since 1996, retaining its initial high level of downy mildew resistance. This hybrid was adopted by increasing number of farmers for its high grain and stover yield, and high level of downy mildew resistance. It reached the highest adoption level of more than 400,000 ha in 2005 (Fig. 2). The hybrid 9444, developed by Proagro Seed Company (now Bayer BioScience), is also highly valued for its high grain and stover yield, and good stover quality (farmers' perception) and downy mildew resistance. This hybrid is also highly tolerant to temperatures as high as 45°C during flowering

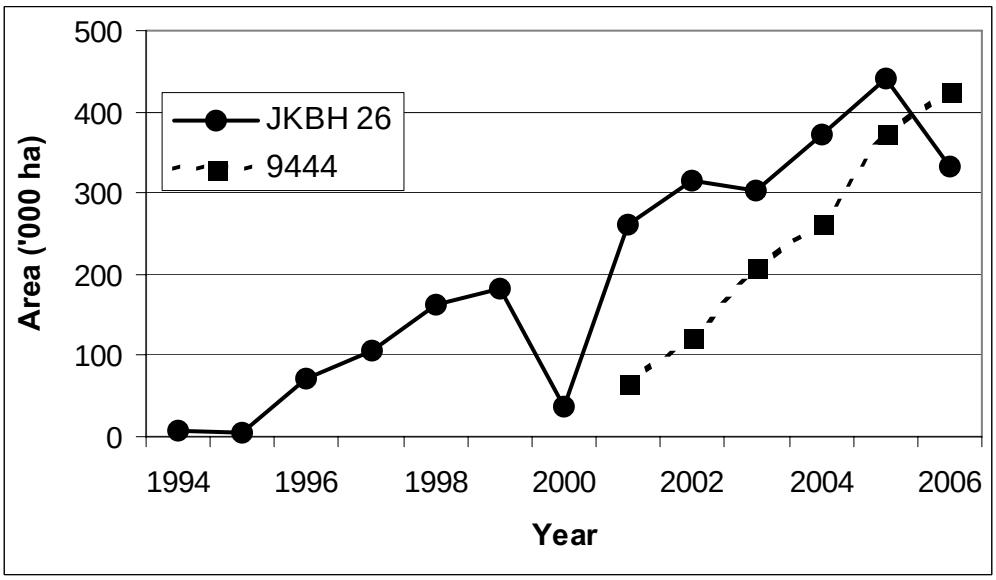

Figure 2. Area planted to widely adopted pearl millet hybrids developed by two consortium member seed companies in India.

Table 3. Farmers' economic benefit from pearl millet hybrid seed production in India.

Input/Output	Mean	Range
A-line		
Average seed yield (kg ha^{-1})	1,683	1,200–1,956
Average price offered (US$ kg $^{-1}$)	0.45	0.36–0.62
Economic return (US$ ha^{-1})	757	432–1,213
R-line		
Average seed yield (kg ha^{-1})	725	500–1,377
Average price offered (US$ kg $^{-1}$)	0.10	0.08–0.12
Economic return (US$ ha^{-1})	73	40–165.28
Average stover yield (kg ha^{-1})	2,320	1,000–3,000
Average price offered (US$ kg $^{-1}$)	0.03	0.02–0.06
Economic return (US$ ha^{-1})	70	20–180
Benefit		
Gross return (US$ ha^{-1})	900	727.78–1091.64
Input cost (US$ ha^{-1})	219	88.89–333.33
Net profit (US$ ha^{-1})	681	638.39–758.31

time. The adoption of this hybrid rapidly increased from 60,000 ha in 2001 to more than 400,000 ha in 2006.

Economic returns from seed production

While the adoption of improved hybrids is the first-level impact of research on farmers' fields, the real impact must be assessed in terms of economic benefit. This is somewhat complicated as we are dealing with mostly unorganized farm sector in India. Pearl millet seed production in India, however, is a highly organized enterprise. While the major share of hybrid seed production profit comes from the seed yield of A-lines and the price offered for it, R-line seed (sold as grain), and stover are priced at about 10% of the seed price of A-lines. There was a large variation across the seed-villages for seed/stover yield, price offered, input cost and net economic returns (Table 3), leading to an average net profit of US$681 ha^{-1}. Apart from this, the seed production enterprise also provided employment opportunities to the rural households

Conclusion

The private sector consortium funding of pearl millet research at ICRISAT in the Asia region has considerably enhanced the Institute's ability to address the core research agenda to generate scientific information, and improved breeding lines and parental lines of potential hybrids as International Public Goods which benefit not only the consortium members but also the public sector programs worldwide. The consortium has been evolving since its inception in 2000 by involving private sector as research partner. The consortium seed companies participate in diverse areas such as providing feedback on changing farmers' perceptions of desirable plant types and grain traits, impact assessment and training programs, and in-kind resource sharing by providing access to their test locations for adaptation research and multilocational field trials. In the years to come, many of them will likely participate in the assessment of on-farm hybrid cultivar diversity, and its effect on productivity and farmers' income. There are good prospects of some of the consortium seed companies developing joint research projects with ICRISAT, taking this public-private partnership to newer heights. In this context, it is to be recognized, as pointed out by Spielman and Von Grebmer (2005), that public-private partnership happens because of common interests of the parties involved. Variability in the incentives do exist, but it is not a constraint because partners agree on mutually acceptable framework that brings order in the system, and makes it more efficient by harnessing the complementary strengths and avoiding unnecessary duplications.

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