Case study of adoption of a pearl millet variety in a non-target region

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Introduction

Cross-pollinated breeding system of pearl millet (*Pennisetum glaucum*), or popularly called *bajra*, provides for open-pollinated varieties (OPVs) and hybrids as the two broad cultivars options. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) initially had a major emphasis on OPVs, leading to the development and release of several OPVs from its breeding programs in Asia and Africa. The first and the most successful among these was WC-C75 developed at ICRISAT, Patancheru from a composite introduced from Nigeria. Released in India in 1982, its average grain yield in 110 trials conducted by the All India Coordinated Pearl Millet Improvement Project (AICPMIP) in all pearl millet growing states was 99% of that of the then most popular and widely cultivated hybrid BJ 104 (Andrews et al. 1985). At the peak of its adoption during late 1980s, it was cultivated on about 1.2 million ha (Rai et al. 2006). However, a comparative study of OPVs and hybrids from several AICPMIP trials showed that hybrids, in general, give 25–30% more grain yield than OPVs (Rai et al. 2006). Thus, as more productive hybrids were produced, WC-C75 was gradually replaced.

ICTP 8203 is a second landmark OPV that was developed at ICRISAT, Patancheru. This variety gave an average grain yield of 1.6 t ha^{-1} (4% less than WC-C75) in 79 trials conducted in India by AICPMIP. However, in 19 of these trials conducted in Maharashtra, it yielded 2.1 t ha^{-1} (7% more than WC-C75); and in 11 trials in Andhra Pradesh, it yielded 1.5 t ha^{-1} (11% more than WC-C75). Based on this specific adaptation, ICTP 8203 was released in 1988 for these two peninsular Indian states (Rai et al. 1990). At the peak of its adoption in 1992, this variety was grown on 0.6–0.7 million ha in Maharashtra alone (Bantilan et al. 1998). Continued cultivation of ICTP 8203 in Maharashtra, even with stiff competition from several hybrids released during the past 20 years, is due to its early maturity, drought tolerance, large grain size and dark gray color (the two most preferred grain traits in the state), and excellent adaptation to low fertility soils. Based on seed sale data, Maharashtra is a major state growing ICTP 8203 with >200,000 ha under this variety. Although ICTP 8203 was not released for northern India, it has been adopted in parts of Rajasthan and Uttar Pradesh in this region. Spillovers, according to Shiferaw et al. (2004), play an important role in agricultural research and development. In this paper, we report on the results of a survey conducted to examine what led to adoption of ICTP 8203 in this non-target region where this variety had not been found to be adapted in AICMIP trials.

Methodology

A major farm input distributor in Jaipur, Rajasthan facilitated the identification of ICTP 8203 growing areas and contact persons-cum dealers in Jaipur, Rajasthan; and Agra, Uttar Pradesh. With the assistance of these dealers, the process of data collection became easy and well organized using a questionnaire that covered the subjects such as: (1) socioeconomic issues on how ICTP 8203 got introduced in these two states; (2) reasons for continued cultivation of ICTP 8203; and (3) production cost and returns. The AICPMIP based at Mandor, Jodphur, Rajasthan, operating under the Indian Council of Agricultural Research (ICAR), is the national-level partner of ICRISAT for pearl millet improvement research. It deputed SK Yadav, an experienced pearl millet breeder from AICPMIP, to join this survey on impact assessment to provide inputs in terms of communication in local language, and scientific expertise on pearl millet in general, and on ICTP 8203, in particular.

Information was obtained from 13 farmers growing ICTP 8203, of which two were not included in the economic analysis due to missing information on several aspects. One major distributor, two input dealers and two grain traders also provided information. Two focus group interviews were conducted – one with the local agricultural extension officers in Dausa district of Rajasthan and the other with a group of farmers in Agra, Uttar Pradesh –

and contributed to a better understanding of adoption and cultivation of ICTP 8203 in the area. Two of the extension officers extended assistance to the researchers in the identification of a village with standing crop of ICTP 8203 and elaboration of the questions and responses (ie, scaling-out of the varieties into farmers' villages). In Uttar Pradesh, the main source of information besides the farmers was three input dealers. The latter provided information about the villages and where to locate farmers cultivating ICTP 8203.

Diffusion of ICTP 8203

ICTP 8203, specifically released for Andhra Pradesh and Maharashtra in 1988, found its way to Rajasthan and Uttar Pradesh through the organized network of input dealers in early 1990s. According to a key informant who is one of the major distributors in Rajasthan, the peak of sale of this variety, approximately up to 100 tons per year, was recorded from the late 1990s. The majority of the respondents claimed that the variety was introduced in their farming system by input dealers and through the influence of their co-farmers. The latter's role supports an earlier finding (Ramasamy et al. 2000) that seed materials and information do come from numerous sources but co-farmers are the leading suppliers. The state seed corporations are an equally important source of seed because of their complementary role in disseminating improved cultivars to farmers. Government camps have also been an important mechanism for introduction of ICTP 8203 in the villages visited.

A close look at the dynamics of cultivation of ICTP 8203 in Rajasthan and Uttar Pradesh reveals that dealers and traders who are major actors in the production chain are regarded as 'necessary evils'. They enable the persistence of this variety in spite of enormous trading of new seed materials of hybrids. The successful adoption of ICTP 8203 in non-target areas is a case in point where the tenet of 'seeing to believe' applies. Since the stakeholders, namely the dealers and/or farmer-dealers/ traders, saw the tangible benefits of ICTP 8203 satisfying their food and fodder requirement, the diffusion proceeded without much 'push'. When farmers try to discover the potential of a new material, they go through the process of negotiation, joint decision-making, and self-determination (Roling and Van der Fliert 2000). A fledgling grower of ICTP 8203 has to negotiate with his own socioeconomic resources, especially the cost of production without sacrificing his food and fodder needs. This implies that the success in technology adoption depends on effectively addressing issues related to local economies and organizations where the latter are not merely viewed as sources of inputs but also as key players to facilitate access.

In the seed industry, dealers play a critical role in providing access to good quality seeds. In this study, there were cases where the purity of seeds sold was a key issue especially when there was slack supply. According to seed dealer-respondents, in situations of insufficient seed supply of ICTP 8203, seed retailers sell their seeds directly to farmers in the villages to obtain higher profit of an additional ₹ 10–15 kg^{-1}. There is hardly any system to ensure the purity of seeds, which is a major concern as indicated by farmer-respondents. Among regular customers, the seeds and other inputs are provided on loan or on 'term' basis. Upon harvest, farmers settle their accounts with the input dealers. This has become a cycle among resource-poor farmers. This clearly shows the importance of social networks, which is one form of social capital drawn upon by farmers to ensure their livelihoods.

Farmers' preference for ICTP 8203

Since its introduction in the early 1990s, ICTP 8203 has become a mainstay in the cropping system of resource-poor farm households in the drier areas of Uttar Pradesh and Rajasthan, where it is popularly called '*bhim*' (as per the Hindu mythology, *bhim* is used to characterize strong physique) or '*sher*' (literally means lion). These local names are corollary to the good qualities of this variety. The strong nature is associated with ICTP 8203's ability to grow relatively better than other cultivars even under stress environments such as drought and it also shows good productivity response to favorable growing conditions. Also, ICTP 8203 is not affected by major pests and diseases, which contributes to its popular choice by farmers. True to the names, farmers ranked the good quality of grains as the primary reason for growing ICTP 8203. The grains are highly suitable for the preparation of *roti* (unleavened bread), which is the staple food of most people in these parts of India. *Roti* prepared from the grains of this variety is more palatable, tastier and gives more energy, as told by the farmers. A couple of farmers and extension workers of the Department of Agriculture in Dausa, Rajasthan mentioned that medical doctors have also been recommending *roti* from this specific variety for diabetes-afflicted individuals. This is not quite surprising for nowadays there is an increasing awareness for health foods and pearl millet is one of the several millets that has been found to have several traits related to health (Rai et al. 2008). Recently, research has shown that among a large number of populations that were evaluated, this variety has the highest level of grain iron content (>65 ppm) as well as high zinc content (>45 ppm). Farmers also consider ICTP 8203 fodder as important as the grain.

While pearl millet cannot compete with the profitability of cash crops, household strategies are such that traditional crops are central to household food and fodder security, especially in situations of slack resources and unforeseen droughts. This explains the sustained cultivation of this variety among farmers in dry areas of these two north Indian states (Fig. 1). ICTP 8203 growers regard livestock as wealth and so is their *bhim bajra*.

Figure 1. A farmer beaming with his ICTP 8203 harvest.

Mr RN Yadav of Rajasthan cultivates about one ha of ICTP 8203. His father has been cultivating this for the past 15 years. Since he took over the management of their farm, he never attempted to abandon the cultivation of *bhim bajra* because of two reasons: (1) he is able to get grains, which is the household's source of good quality food and some cash; and (2) most importantly, he gets fodder, which is sufficient to sustain his five livestock. His grain yield of 2500 kg ha^{-1} fetched him a net profit of ₹ 17085 (US$ 438) ha^{-1}, while the fodder of about 5500 kg ha^{-1} was stored entirely for his livestock.

Based on Yadav's experience, ICTP 8203's fodder and grain quality as well as yield have not been surpassed by other varieties/hybrids grown in similar conditions where they presently grow ICTP 8203. Grains of this variety have high demand in the market as food. There is also demand for fodder but he said that most farmers in his village keep this for their own livestock's use. Because of this, he regards pearl millet and livestock as his major assets. The only constraint he is faced with cultivation of ICTP 8203 is the deteriorating quality of the seeds he buys from input dealers. He and his co-farmers believe that input dealers sell adulterated *bhim bajra* seeds nowadays. He premised this on his observation of decreasing yield for the last five years. He relates that it has been quite difficult to buy seeds from the dealers' shops due to high demand and less supply. Input dealers go to the villages selling the seeds, which is similar to a 'black market' system. This, in turn, costs more to the farmers. According to Yadav, in spite of farmers' awareness of this scrupulous system of seed sale, they did not opt for hybrid seeds due to higher perceived risks of failure with materials that they have not much knowledge.

This shows the significance of well-familiar crops including varieties and the intricacy of addressing users such as farmers' concerned with a better livelihood system. The cultivation of ICTP 8203 is a case where farmers inevitably need to negotiate with their practices and capacities such as the decision-making process whether to alter the existing farming system (ie, for instance, changing the crop cultivars such as ICTP 8203 with hybrids). What ensues, more often than not, is a decision revolving around specific needs and events of the farmer. It becomes central to the farmer to access resources (both physical and knowledge system) with which he can maneuver in order to realize his objectives.

The way in which people deliberate on their future determines their actions. With Yadav's livelihood revolving around livestock, he has to put together his actions for satisfaction not only of his grain requirement, but also the fodder requirements. In doing so, past experience or history (Long and Van der Ploeg 1995) is relevant for ordering the future. Hence, the rationale for Yadav's incessant cultivation of ICTP 8203 is hinged on factors borne out of his familiarity with the crop and the variety. A farmer as a social actor takes cognizance of practices, which are set in time and space when he negotiates with the material and physical environment.

Although the total area under ICTP 8203 in Rajasthan and Uttar Pradesh is yet to be assessed, there has been partial displacement of ICTP 8203 by hybrids in the late 1990s. According to dealers, some of the authentic seeds of ICTP 8203, which they have sold, seems to be losing its productivity. However, two breeders from Nirmal Seed Company (a major supplier of the seed of this variety in Rajasthan and Uttar Pradesh) pointed out that the demand for ICTP 8203 will likely increase even after 10 years due to the unpredictable and erratic rainfall. Farmers will likely opt to grow crops like pearl millet, specifically a variety such as ICTP 8203, which is not so much affected by climate variability.

Economic benefit from ICTP 8203 cultivation

The total landholding size of the farmers included in this survey varied from 1 to 23 ha with an average of 6 ha (Table 1). The area under pearl millet cultivation varied from 0.25 ha to 2.0 ha with an average of 0.9 ha. Based on farmers' responses, large variation among the farmers'

fields was found both for grain yield (1040 to 4800 kg ha^{-1}) and dry stover yield (2500–13400 kg kg^{-1}). This could be partly due to differences in the inherent soil quality, but it surely must have also resulted from large variation in seed rate, seed quality and crop management. For instance, the average seed rate of 5.25 kg ha^{-1} found in this study was slightly more than the normal seed rate of 4 kg ha^{-1} recommended for pearl millet, but for the large-seeded variety ICTP 8203, it can be considered as optimum seed rate. Two farmers used seed rate as high as 7.5 and 8.8 kg ha^{-1}, which is not unexpected as farmers use higher seed rate to account for any poor germination and poor emergence due to soil surface crusting. Farmers having greater emphasis on fodder also use higher seed rate. Surprisingly, one farmer used very low seed rate of 2.4 kg ha^{-1}, which could be due to timely unavailability of the seed. The seed cost of an OPV is not an important consideration for using low seed rate because on a per ha basis, the average seed cost was only ₹ 244 (US$ 6.26), which is 4% of the total production cost (₹ 6158 or US$ 158), the lowest among all the production inputs such as fertilizer and farmyard manure (where applied) and labor cost for crop management and postharvest handling. The farmer who used the lowest seed rate had the lowest grain yield (1040 kg ha^{-1}) as well as stover yield (2500 kg ha^{-1}). This farmer made the lowest investment in other inputs, and thus the benefit-cost ratio was lowest (0.83). The highest grain yield of 3200–4800 kg ha^{-1} and stover yield of 10000–13400 kg ha^{-1} was obtained by the farmers who used optimum seed rate of 4–5 kg ha^{-1}. Incidentally, these farmers also made the highest investments of ₹ 5000–13000 (US$ 128–333) ha^{-1} in crop management, harvesting and postharvest handling of the crop, implying that some farmers were more aware of the better crop management practices, or at least were responsive to the use of better crop management practices. This showed the need for enhanced extension services promoting best-bet crop management technologies for enhancing pearl millet productivity and profitability. An old variety like ICTP 8203 is still thriving well provided good quality seeds are made available to farmers.

Table 1. Economic benefit of ICTP 8203 cultivation in the non-target region of northern India.

Production variable	Range	Average
Total size of landholding (ha)	1–23	6
ICTP 8203 area (ha)	0.25–2.0	0.9
Seed used (kg ha^{-1})	2.4–8.8	5.25
Grain yield (kg ha^{-1})	1,040–4,800	2,666
Stover yield (kg ha^{-1})	2,500–13,400	7,560
Gross income[1]		
Gross income from grains[2] (₹ ha^{-1})	5,460–24,960	15,569
Gross income from stover[3] (₹ ha^{-1})	2,500–13,400	7,560
Total gross income (₹ ha^{-1})	7,960–38,360	23,169
Production cost		
Cost of seeds (₹ ha^{-1})	92–410	244
Cost of fertilizer (₹ ha^{-1})	300–1,404	692
Cost of farmyard manure[4] (₹ ha^{-1})	1,600–6,000	1,220
Cost of land preparation (₹ ha^{-1})	200–2,353	1,123
Cost of hoeing, weeding, etc (₹ ha^{-1})	500–1,295	1,014
Cost of harvesting (₹ ha^{-1})	500–1,765	973
Cost of threshing (₹ ha^{-1})	333–1,250	442
Cost of transporting (₹ ha^{-1})	59–800	268
Cost of loading (₹ ha^{-1})	59–800	347
Total production cost (₹ ha^{-1})	3,738–13,146	6,158
Net income (₹ ha^{-1})	3,603 – 33,355	17,000
Benefit-cost ratio	0.83–6.7	2.76

1. Exchange rate at interview: 1 US$ = ₹ 39.
2. Price of grain: ₹ 5.20–6.75 per kg.
3. Price of stover: One rupee per kg.
4. Manure applied every 2–3 years.

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