Two features of the large-scale cultivation of rice are relevant to the present study:

1. the widespread transplanting of rice early in the season, contrary to extension recommendations
2. trends in varietal adoption, such as the widespread cultivation of a single variety

We discuss these issues here and present evidence in support of an alternative approach to that of conventional extension: participatory varietal selection for new varieties.

Issues related to rice cultivation in the Punjab

Early transplanting

Time of transplanting is a major factor that substantially influences rice yield. A transplanting schedule has been recommended by the Punjab Agricultural University (PAU) to get the highest yield and prepare the fields in time for the following wheat crop. It is recommended that varieties Jaya, IR8, and all Punjab rice (PR series) varieties should be transplanted from 10–20 June, with the exception of the early-maturing variety PR103, which should be transplanted from 20–30 June. PAU has issued a general guideline stating that where the rice area is large, the transplanting period should extend equally around 20 June (PAU 1996).

Surveys conducted in the Punjab (Singh 1998, 1999) over four years (1996–1999) revealed that transplanting in the Punjab starts from 1 May (figure 1). By the end of May, about 22% of the rice crop is transplanted, and by the middle of June, about 65% of the crop is already in the field. This early planting is more conspicuous in the Patiala district, where about 50% of the rice is transplanted by the end of May and 89% by mid-June.

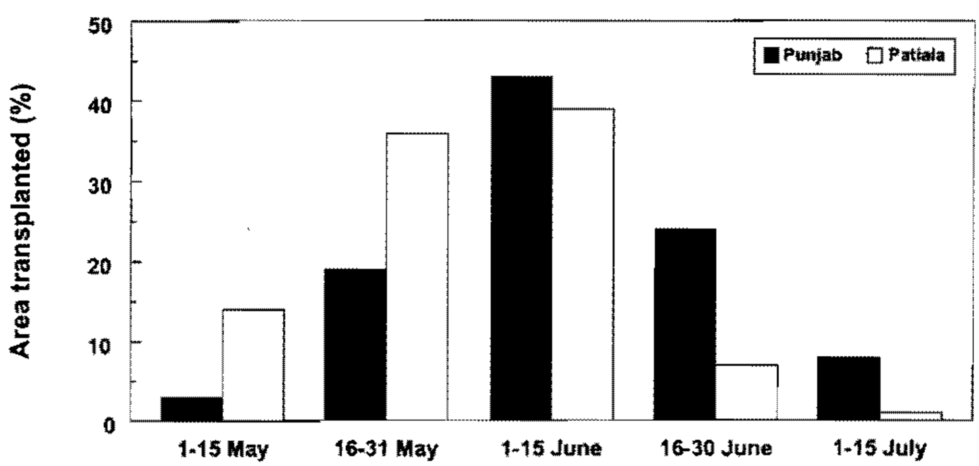

Figure 1. Rice area transplanted from 1 May to 15 July in Punjab and the project area of the Patiala district
(The averages are over four years (1996–1999), based, for Punjab, on a sample of 1076 farmers in 11 districts in 1996 and 1997, and 855 farmers in 1998 and 1999; in Patiala, based on a sample of 105 farmers in 1996 and 1997, and 100 farmers in 1998 and 1999.)

Why farmers practice early transplanting contrary to extension recommendations is an interesting question. Participatory rural appraisals (PRAs) done with farmers reveal some of the reasons farmers transplant late:

- the availability of tube-well irrigation and a cheap, flat rate for electricity
- the continued employment of labor after the wheat harvest
- the limited choice of early-maturing varieties, since high-yielding cultivars tend to have longer maturation periods and need earlier transplanting

Early transplanting of rice has led to multiple problems such as the following:

- a lowering of the water table from greater exploitation of ground-water resources (During May and June, the water requirements for crops are at their peak. The early transplanted crop requires 20% to 30% more water [PAU 1996].)
- the loss of nutrients from evaporation in the extremely hot months, resulting in increased use of chemicals and degradation of the environment
- an increase in diseases and insect pests
- less opportunity for green manuring

Specific varietal adoption patterns

Old varieties are cultivated on a large area. PAU has recommended a number of varieties of rice; however, farmers still prefer to grow old varieties. The varietal surveys conducted by PAU's senior extension specialist (farm management) showed that 36% of the area in the state during 1999 was occupied by varieties released 15 years ago, e.g., PR 106, IR8, Jaya, PR 103, and Govind (Singh 1999).

Weighted average age of varieties is high. The average age of varieties, weighted by the area grown to them in the Punjab, was 12 years in 1996, 11 years in 1997, and 10 years in 1998 and 1999. This average is very close to the 12 years reported by Witcombe et al. (1988) for the whole of India. More recently, farmers have replaced their varieties more rapidly, but the average age remains higher than what could be expected of an agriculturally advanced state. Varieties of wheat and barley grown in the UK in 1999 had an average age of only five years (analysis of data from the National Institute of Agricultural Botany by A.G. Bhasker Raj, *personal communication*).

Nonrecommended varieties occupy large areas. Despite many recommendations by PAU, there is significant adoption of nonrecommended varieties in the state. In fact, the area under non-PAU varieties increased in 1998 and 1999 (table 1).

In Patiala, the adoption of nonrecommended varieties was higher than in the Punjab as a whole (average of 53% over four years). Among nonrecommended varieties, Pusa 44 has the highest adoption. It occupied nearly 50% of the area in the Patiala district in 1996 to 1999. Pusa 44 is highly susceptible to bacterial leaf blight (BLB), and the large-scale cultivation of Pusa 44 has helped to build up the BLB pathogen, which causes losses in other varieties. However, farmers prefer Pusa 44 for its high yield and resistance to lodging.

Table 1. Area of Nonrecommended Varieties in the Punjab and Patiala District from 1996 to 1999

	Area of nonrecommended varieties (% of total rice area)		Area of Pusa 44 (% of total rice area)	
Year	Punjab	Patiala	Punjab	Patiala
1996	31	43	24	43
1997	33	47	28	47
1998	35	60	30	56
1999	38	60	28	54
Mean	34	53	28	50

Note: See figure 1 for information on sample sizes.

Methods and materials

Participatory approaches

Three participatory approaches were used in this study:

1. farmer-managed participatory-research (FAMPAR) varietal trials, in which farmers grow new varieties alongside their local variety under farmer management, with evaluation of many cultivar traits by both scientists and farmers
2. informal research and development (IRD), in which farmers evaluate new varieties with little intervention from scientists; evaluation is mainly from the examination of adoption trends
3. single-replicate design (mother trials), with all varieties grown together as demonstration plots to assess the relative performance of varieties (researcher-designed but farmer-managed trials)

Selection of farmers and villages

Eleven villages (Kalifewala, Chalaila, Kalwa, Barsat, Bhedpura, Gajjumajra, Kaidopur, Dhengera, Partapgarh, Kartarpur, and Jauramajra) were selected to represent agroclimatic situations in the Patiala district. Three villages (Gajjumajra, Bhedpura, and Barsat) represented salt-affected areas with soils having a pH between 9.0 and 9.5. Of these 11 villages, FAMPAR trials were conducted in six and IRD in the rest. All villages have either metaled or good earthen approach roads. All of the agricultural land is irrigated from canals or tube wells.

Farmers were selected to represent small, medium, and large landholdings. Willingness to experiment with new varieties was the key factor in selecting farmers. A total of 497 farmers were involved in participatory research in the *kharif* (monsoon season) of 1999.

Farmer-managed trials

Twelve varieties were tested in participatory trials: IR36, IR64, HKR 120, HKR 126, Pant Dhan 4, Pant Dhan 10, Gurjari, Kalinga III, Govind, Pusa 834, PR 111, and PR 114. Of these, varieties, PR 111 and PR 114 are recommended for the Punjab. All other varieties are out-of-state released varieties. Small bags (2–5 kg) of seed (varying according to the demand of farmers) were given to farmers with the understanding that they would grow the new variety alongside their local variety under the same management and that they would participate in the evaluation.

The plot area for FAMPAR trials varied from 40–5000 m^2. Most trials had an area of more than 1000 m^2 under any variety. Some farmers, particularly in IRD villages, pooled the seed to grow a larger area.

Researchers and farmers jointly evaluated the trials. Frequent farm walks, focus-group discussions, and household-level questionnaires were used for recording farmers' perceptions. Grain yield data were recorded jointly; researchers measured the plot size and farmers weighed the plot yield.

Demonstration plots of all varieties grown in the same field in a single-replicate trial were grown in all villages as mother trials.

Results and discussion

Of the 12 varieties tested with farmers, three (IR64, IR36, and PR 114) were preferred but IR64 was the most preferred. We shall restrict the description of trials to IR64 only. Variety IR64 was tested with 43 farmers (26 in FAMPAR villages and 17 in IRD villages) and compared to Pusa 44.

Farmer trials over several dates of sowing

The greatest power of participatory trials was experienced in this study when IR64 was tested over a span of time representing the whole of the transplanting period in the Punjab. This was not deliberately designed but was a result of the reasonably large sample size that represented the normal practices of farmers. This was not possible in earlier on-station trials that were invariably sown over a restricted, usually late, period. These on-station trials, done in 1985, 1986, and 1987, did not identify IR64 because it yielded less than the check varieties in trials that were transplanted in July.

Performance of IR64

IR64 had a significant yield superiority of 5% over Pusa 44 in 43 trials, giving an extra 300 kg of grain ha^{-1} over a base of 6550 kg (figure 2). IR64 showed the best performance (a 12% yield increase over Pusa 44) when transplanted from 21–24 June. The yield advantage decreased when IR64 was transplanted earlier or later in June, which fits very well with the extension recommendation to spread transplanting equally around 20 June.

An important feature of IR64 is that it matures 26 days earlier than Pusa 44. This trait, along with high yield, favors its adoption in various situations (figure 3).

Farmers' perceptions for traits other than grain yield (figure 4) identified IR64 to be superior to Pusa 44 for number of tillers per plant and resistance to BLB, stem borer, and leaf folder. IR64 is shorter so it is resistant to lodging, which allows it to be responsive to inputs.

Advantages of IR64 over Pusa 44

IR64 had the following advantages over Pusa 44:

- superior grain quality and higher yields
- earlier maturity, leading to a saving of irrigation water
- resistance to BLB and tolerance to white-backed plant hoppers
- resistance to lodging

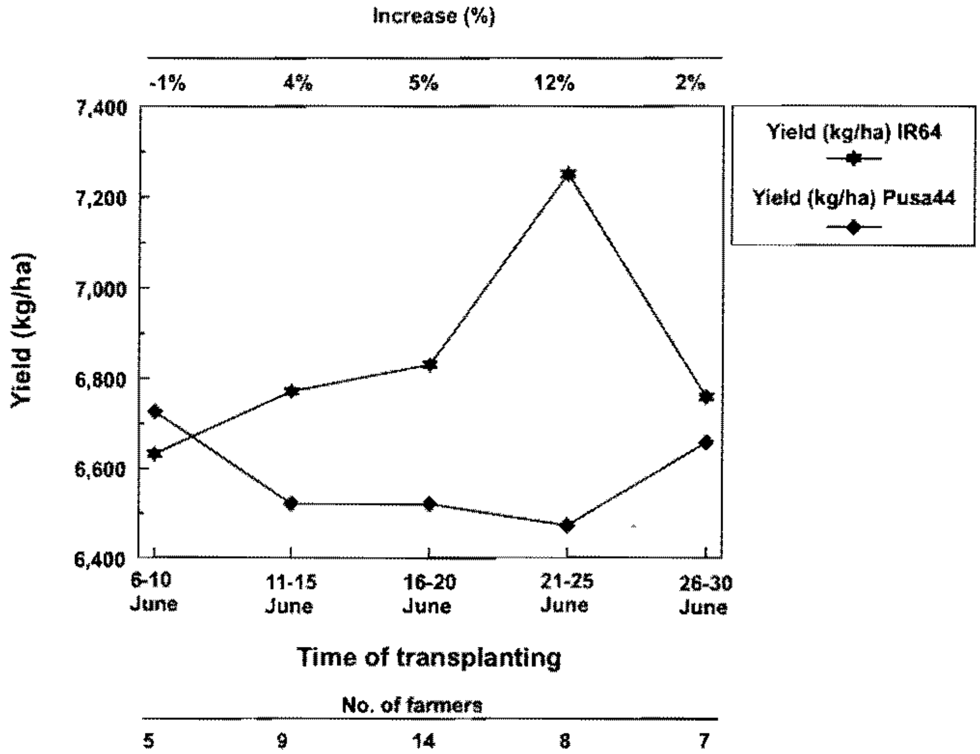

Figure 2. Yield (kg ha^{-1}) of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (The overall mean yield of 6860 kg ha^{-1} of IR64 was significantly higher [at the 1% level] than the 6550 kg ha^{-1} yield of Pusa 44 with a *t*-value of 4.1 over 43 sites.)

- allowing a green-manure crop or summer mung (*Vigna radiata* [L.] Wilczek) to be grown between the wheat harvest and rice transplanting

Adoption and further testing of IR64

All participating farmers saved IR64 seed in 1999 for growing in *kharif* 2000. There was considerable seed exchange from farmer-to-farmer. Seed demand in *kharif* 2000, from farmers who had seen the trials was considerable, but only five tones of seed could be procured and supplied to farmers. Some entrepreneurial farmers and farmers' groups in the state have already become active in producing and procuring IR64 seed.

As a consequence of the participatory trials in Patiala, PAU is retesting IR64 at a number of research stations under appropriate management. The Krishi Vigyan Kendra (KVK), Patiala, has undertaken large-scale testing on farmers' fields in Patiala and other districts of the Punjab in *kharif* 2000.

To exploit the advantage of IR64's early maturity, new agronomic practices and cropping patterns are being tested by the KVK Patiala in more than 40 trials with farmers. These are on growing summer mung and green manuring with sesbania in *kharif* 2000.

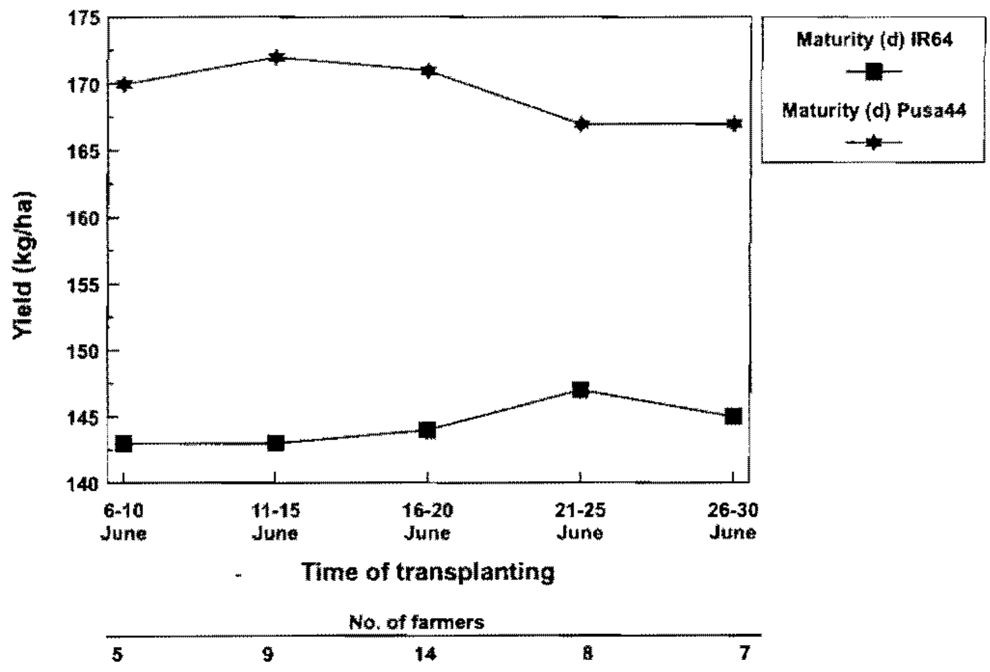

Figure 3. Days to maturity of IR64 and Pusa 44 in 43 farmers' field trials (26 FAMPAR and 17 IRD) in the Patiala district during the monsoon season of 1999 (Over 43 trials, IR64 matured significantly earlier [144 days] compared to Pusa 44 [170 days].)

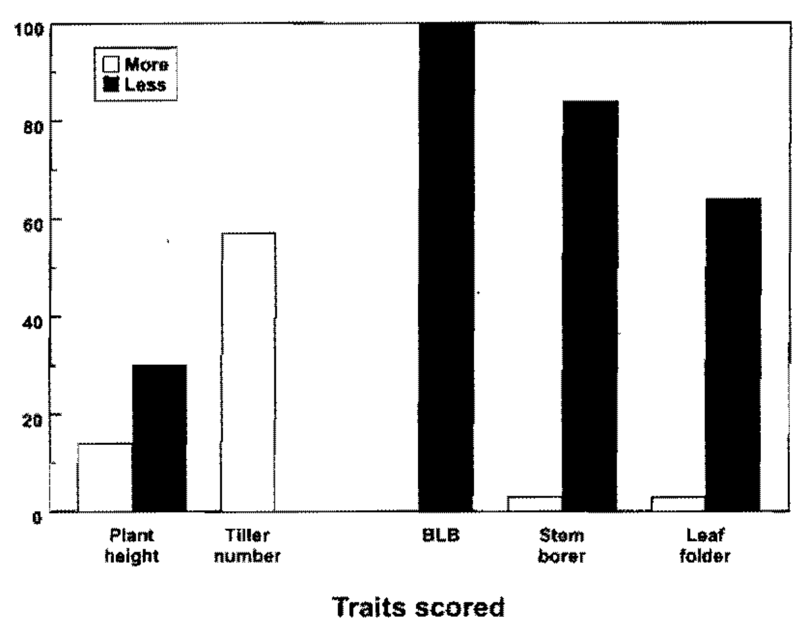

Figure 4. Farmers' perceptions (%) for IR64 in comparison to Pusa 44 for plant height, tiller number per plant, and resistance to bacterial leaf blight (BLB), stem borer, and leaf folder over 48 farmers (Like Pusa 44, IR64 was found to be 100% lodging resistant.)

Conclusions

The PVS approach has been shown to be a potent tool:

- to identify farmer-preferred varieties
- to identify the correct recommendation domain of a variety (IR64 was previously tested in formal trials but was rejected for the Punjab because formal testing did not represent the temporal variability that exists in high-potential production systems)
- to correctly determine the best time of transplanting of a variety
- to identify varieties that give farmers new agronomic options
- to promote the rapid adoption and dissemination of a variety

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Equity Issues in Varietal Dissemination through Farmers' Fairs (*Kisan Melas*) in Punjab, India

J. Singh, S.S. Malhi, J.R. Witcombe, and D.S. Virk

Abstract

In the Punjab state of India, grain production has rapidly increased. One factor in this increase has been the fast adoption of new varieties. Punjab Agricultural University (PAU) has played a major role in distributing certified seed of new varieties to the farmers of the state. Most of the seed is distributed by sales at farmers' fairs (*kisan melas*) held at PAU and its regional research stations. In this study, equity issues in the sale of wheat seed were examined in farmers' fairs held in September 1999.

In the PAU *kisan mela*, smallholder farmers were found to be considerably underrepresented and large farmers considerably overrepresented. The geographical distribution of the farmers who purchased seed was also studied. As might be expected, farmers tended to come to where the *kisan mela* was held from nearby administrative areas (termed *blocks*). This resulted in certain blocks being poorly represented.

PAU needs to address equity issues, both socioeconomically and geographically, by increasing the outlets for seed sales in remote districts and areas of the state, and by encouraging small farmers to attend the *kisan melas* and purchase seed.

Introduction

The Punjab State of India has witnessed a rapid increase in the production of food grains, particularly wheat. Wheat production was only 1.74 million tonnes in 1960–61, but it rapidly increased to 14.46 million tonnes in 1998–99 as a result of increases in both yield and the area under the crop. Wheat yields averaged only 1.2 t ha^{-1} in 1960–61, but this increased to reach 4.3 t ha^{-1} in 1998–99. This very large increase in productivity was due to several factors, including the breeding and popularization of high-yielding varieties (HYVs), increased irrigation and fertilizer use, and the mechanization of farm operations. The fast adoption of quality seed was a major—perhaps the most important—factor.

A survey of the wheat crop in the Indian Punjab (Singh 2000) showed that 79% of farmers kept seed from the previous crop, 12% purchased from private seed dealers, and 6% kept part of the seed and purchased part from seed traders. Only 3% of farmers practiced farmer-to-farmer seed purchase. About 4% of the purchased seed was bought from institutional sources such as the Punjab Agricultural University (PAU), the Punjab State Seeds Corporation, or the National Seeds Corporation. However, for new varieties, farmers tended, in the beginning at least, to purchase seed from PAU.

PAU produces and disseminates seed. Its primary responsibility for production is breeder and foundation seed. However, it also produces certified seed of recommended varieties and, for wider dissemination, recently released varieties. Most of this certified seed is distributed during farmers' fairs (*kisan melas*) that are held at the main campus at Ludhiana (PAU *mela*) and at four regional research stations (RRSs) situated at Rauni, Bathinda, Ballowal Saunkhari, and Gurdaspur. In this

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study, we examine the equity issues in PAU's wheat-seed distribution system at the time of the farmers' fairs.

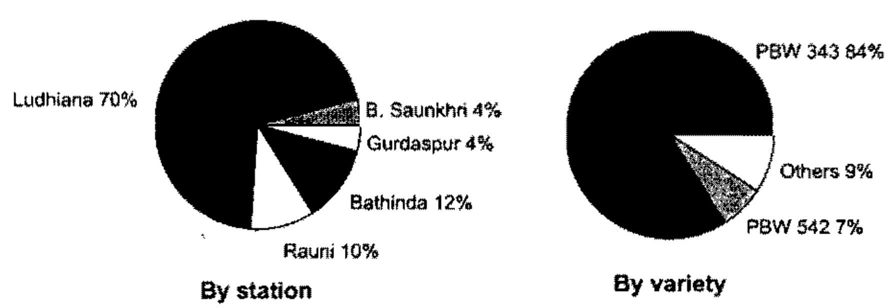
Methods

PAU holds farmers' fairs twice a year at the main campus and at four RRSs. At the fairs, certified or truthfully labeled seed is sold for the *kharif* (monsoon season) and *rabi* (winter season) crops. The seed is sold on a "first-come-first-served" basis—farmers queue for their turn to buy seed for cash. In September 1999, wheat seed sales at the five *kisan melas* were surveyed by distributing a simple questionnaire to the farmers in the queues. There was a random sample of 359 farmers who purchased wheat seed at the PAU campus *mela* and a random sample of 285 farmers at the RRS *melas*. Farmers were asked about their farm size, the location of their farm and the amount of seed they had purchased.

Results and discussion

Station-wise and variety-wise seed sales

Nearly 28 t of wheat seed was sold in all *kisan melas*. A major share of the seed was sold at Ludhiana (70%) because it is centrally placed and is the main campus of the university (figure 1). When farmers visit Ludhiana for seed purchases, they also have the opportunity to learn about other technologies. Also, this *mela* is widely advertised and is a more significant event than the regional *melas*. After the PAU campus, Rauni (10%) and Bathinda (12%) accounted for most of the remaining seed sales (figure 1).



Source: Director of Seeds, PAU and Ludhiana, personal communication.
Note: "Others" include varieties PDW 233 (1.8%), PBW 138 (2.1%), PBW 175 (0.3%), PBW 299 (0.4%), PBW 373 (2.5%), and PBW 396 (1.7%), all of which individually account for less than 5% of seed sales.

Figure 1. Wheat-seed sales of PAU at the main campus and regional research stations

Melas at Gurdaspur (4%) and Ballowal Saunkhari (4%) do not account for major sales of wheat seed. Gurdaspur is located on the northern corner of the state and is not well connected. Ballowal Saunkhari represents the mainly rainfed *kandi* belt of the state—a 10 km tract adjoining the hilly state of Himachal Pradesh, where irrigation facilities are very poor. Farmers in this area largely belong to the low-resource category.

Variety PBW 343 was in the greatest demand and accounted for 84% of the total seed sales (figure 1). The only other variety to account for an appreciable proportion of seed sales was WH 542 at 7%. The remaining five varieties accounted, in total, for only 9% of the sales.

Patterns of seed distribution in addressing equity issues

Overall seed distribution in the state in all *kisan melas*. A large proportion (45%) of the farmers in the Punjab have small landholdings of fewer than 5 acres. These farmers own only 12% of the cultivable land (table 1). In contrast, 29% of farmers who have more than 10 acres own 67% of the cultivable land (table 1).

Table 1. Patterns of Wheat-Seed Sales at Farmers' Fair at PAU, Ludhiana, September 1999

Farm size	Farmers attending the *mela*		Quantity of seed sold		Proportion of farmers in the state by	
(acres)	Number	%	Tonnes	%	Number (%)	Area (%)
< 5	20	6	0.9	5	45	12
5 to 10	49	14	2.0	11	26	21
10 to 20	125	35	6.1	35	23	40
> 20	165	46	8.7	50	6	27

When farmers attending all the *melas* were categorized by the size of landholding, it was found that smallholder farmers with fewer than five acres were extremely underrepresented (7% of purchasers versus 45% of the farmers as a whole). The 7% of the farmers from this category purchased 6% of the seed sold (figure 2). In contrast, farmers with large landholdings were hugely over-represented (46% of purchasers but only 6% of the farmers in the state). Less marked, but nonetheless quite large, underrepresentation occurred for farmers in the five- to 10-acre landholding category, and there was overrepresentation for farmers in the 10- to 20-acre category (figure 2). A similar, but less marked, bias was found for seed quantities purchased relative to the area of land held by each category of farmer (figure 2).

Seed sales as a percentage of total sales varied little from the data for farmers purchasing seed, i.e., once farmers decided to purchase seed, there was little difference in the quantity purchased, whatever the category of farmer.

The same analysis was done, disaggregated into the PAU *mela* (table 1) and the regional *melas* (table 2). Although, in both cases, there was underrepresentation of smallholder farmers and over-representation of larger landholding farmers, the situation was better in the regional *melas*. The biggest difference between the regional *melas* and the Ludhiana *mela* that there were fewer large landholding farmers purchasing seed (46% in the Ludhiana *mela* compared to 28% in the regional *melas*).

Spatial coverage

The geographical distribution of the farmers who purchased seed was also studied. The Punjab state is divided into 136 administrative units, called development blocks, that represent clusters of contiguous villages. As expected, farmers tended to come from nearby administrative areas or blocks

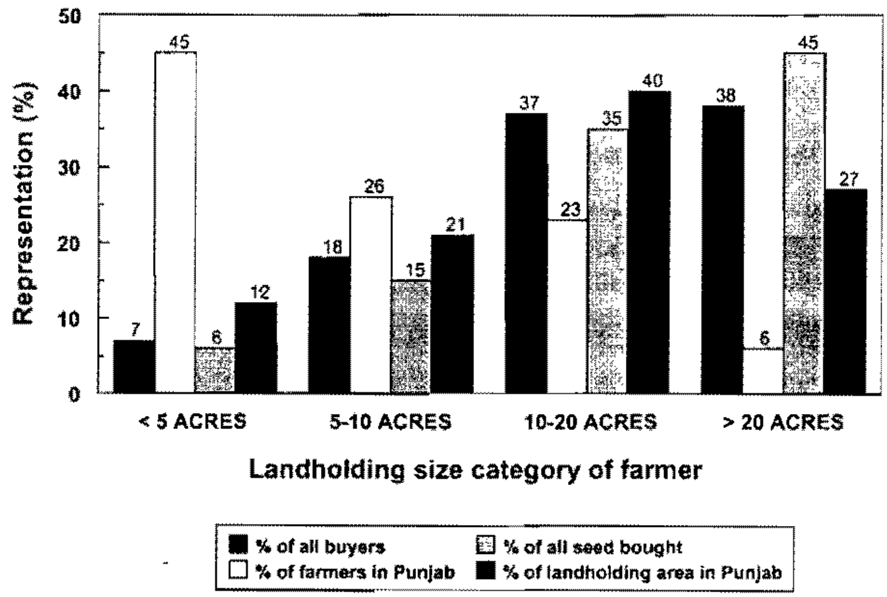


Figure 2. Wheat-seed sales by PAU at its main campus and four regional research stations, categorized by landholding size
(Sales by number of purchases and quantity of seed purchased are compared to the number of farmers and the area of land in the state by the landholding categories. The data presented are from a random sample of 644 farmers: 359 at the main campus and 285 at regional research stations.)

Table 2. Patterns of Wheat-Seed Sales at Farmers' Fair at Four PAU Regional Research Stations, September 1999

Farm size	Farmers attending the mela		Quantity of seed sold	
(acres)	Number	%	Tonnes	%
< 5	25	9	0.9	7
5 to 10	65	23	2.4	19
10 to 20	114	40	4.5	36
> 20	81	28	4.7	37

to where the *kisan mela* was held. Farmers who visited *kisan melas* at the main campus and RRSs belonged to 95 blocks out of 136 blocks in the Punjab.

In the PAU campus fair, the farmers sampled came from 65 development blocks of the Punjab state. Farmers also came from nine development blocks of the surrounding states of Haryana and Rajasthan. In the regional fairs, farmers came from 59 development blocks to buy seed. The geographical distribution at block level shows the following:

- Seed is only disseminated to 70% of the blocks in the Punjab despite the five kisan melas in the state. Forty-one blocks showed no representation among the farmers who were sampled.

- The majority of underrepresented blocks were in the Amritsar and Ferozepur districts where no fairs are presently held.

PAU developed its seed-dissemination system in the post-Green-Revolution period to improve the equity of seed distribution in the state. In this system, small kits of seed are sold to many farmers rather than larger quantities being sold to a few better-off farmers. When it was felt that farmers from remote areas were unable to travel to the main campus in Ludhiana, regional kisan melas were started in order to make seed available in the regions. However, the seed-dissemination system of PAU at present does not address these issues satisfactorily. It is not known if these equity issues have always been present or if they have worsened over time. It is possible that over years, small farmers and those in remote geographical areas have become less enthusiastic about traveling to kisan melas, and small farmers have become dependent on larger farmers for their seed supply. Another factor may be that farmers with smaller landholdings are less prepared to take the risk of trying new varieties immediately after their release and wait until they can judge their performance on the fields of better-off farmers in their village. Why small farmers have lower representation in melas and why they buy less seed are important issues that need to be addressed.

Large farmers, who generally employ labor for farm operations, can afford to be away from their farms. They have the means and the time to travel long distances to purchase seed to increase farm revenues. On the other hand, small farmers

- lack the resources to travel long distances
- lack time because of their involvement in farm and off-farm activities, particularly in September when they are busy attending to the maturing rice crop
- lack sufficient funds to purchase seed at the time when they have incurred heavy expenditures on the standing rice crop, and have yet to gain a return from it
- perhaps lack enthusiasm to try new varieties because their possible failure represents for them a greater risk to their livelihoods than it does for larger farmers

Although not ideal, the representation of small farmers is slightly better at the regional fairs because, on average, seed purchasers have traveled less far. Even there, they buy seed in smaller quantities than their representation. Small farmers require smaller quantities of seed because of their small landholdings, but this may also indicate that they lack money to buy more and that they have greater aversion to risk than large landholders.

Despite the sale of seed at regional stations, there are 41 blocks that were not served by the system in the sample. Most of these are in the border districts of Amritsar and Ferozepur where there are no RRSs. Ferozepur borders on Haryana and Rajasthan. Lack of availability of seed from sources in the Punjab probably leads to a higher adoption of varieties from adjoining states.

Conclusions

The PAU system needs to open more outlets for seed sales to address both equity issues. If new regional stations cannot be opened in the Amritsar and Ferozepur districts, *kisan melas* can be held in these districts in collaboration with the Department of Agriculture. More *kisan melas,* especially in poorly served blocks, may also help address the needs of small farmers in the state. Policies at the state level, involving Punjab State Seeds Corporation and the Department of Agriculture, that are

more smallholder-farmer friendly need to be formulated and adopted. Extension workers could create greater awareness among small farmers of the benefits of replacing seed more frequently and adopting new varieties earlier. One way of doing this is to encourage farmer experimentation by recommending that farmers try new varieties on a small area to compare them to the existing variety (see Malhi et al., this volume).

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Participatory Varietal Selection in Rabi Sorghum in India

B.S. Rana, S.L. Kaul, Chari Appaji, Parbhakar, N.S. Kalyanshetty, B.V.S. Reddy, J.R. Witcombe, and D.S. Virk

Abstract

Sorghum is the third most important cereal crop in India and, over both the rainy (*kharif*) and the post-rainy (*rabi*) seasons, totals a combined area of more than 11 million ha. *Rabi* sorghum is important for both food and fodder in the drought-prone areas of the states of Maharashtra (3.3 million ha), Karnataka (1.5 million ha), and Andhra Pradesh (0.45 million ha). Genetic enhancement and technology development have doubled the productivity of *kharif* sorghum. Progress in *rabi* sorghum has been slower because of several factors, such as more prevalent drought, shoot-fly infestations affecting the initial plant stand, low response of landraces to applied nutrients, and a limited choice of cultivars that have the traits required for adaptation to the *rabi* season. As a consequence, farmers continue to grow the cultivar M 35-1, developed in 1935, that was a selection from the Maldandi landrace. A participatory varietal selection program for *rabi* sorghum, to overcome the lack of cultivar choice, is described in this paper.

Introduction

Participatory varietal selection (PVS) provides an opportunity for farmers to select one or more varieties from a basket of recently developed genotypes from plant breeding programs. Witcombe et al. (1996) reported that if a suitable choice of cultivar exists, PVS is a more rapid and cost effective way of identifying farmer-preferred cultivars than conventional, transfer-of-technology, extension methods.

In India, Maurya, Bottrall, and Farrington (1988) tested advanced lines of rice with villagers in Uttar Pradesh and successfully identified superior material that was preferred by farmers. Also in India, Joshi and Witcombe (1996) identified farmer-acceptable cultivars of rice and chickpea from a range of released and nonreleased cultivars tested in farmer-managed participatory trials. Farmer-acceptable cultivars were found among released varieties but not among those recommended for the area.

Relevance of PVS in *rabi* sorghum

The participatory approach to varietal selection is considered valuable when formal breeding and seed-supply systems have been unable to fulfill the needs of users. This often occurs where the agroecological or socioeconomic environment differs significantly from those anticipated and tested for in the formal system of variety testing. In *rabi* sorghum, several factors mean that PVS could be a useful approach: low adoption of improved cultivars, variable growing conditions and multiple production constraints in farmers' fields that are difficult to simulate on the research station, and local preferences for grain quality.

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Activities

Six nongovernmental organizations (NGOs), six centers of the All-India Co-ordinated Sorghum Improvement Project (AICSIP) located in state agricultural universities, the National Research Centre for Sorghum (NRCS), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) collaborated in the research. The activities involved the identification of villages, NGO user groups and farmers in those villages, and the conducting of rapid rural appraisals (RRA) to identify which varieties farmers cultivated and how they cultivated them, as well as to assess constraints to productivity. Farmer-managed trials of 10 or more identified elite varieties, hybrids, and selected local control varieties were conducted by farmers on their fields. Joint monitoring by researchers and farmers was done at a minimum of three crop stages, and data were collected on the performance of the entries. before the *rabi* sowing, the NGOs selected the participating farmers by organizing group discussions that included both farmers and officials.

Materials

AICSIP has continuously developed new dual-purpose cultivars with *rabi*-adapted traits, such as resistance to drought, shoot-fly, and charcoal rot. It has involved direct selection from landraces, as well as hybridization and progeny selection. Genotypes in the trials included several that were developed and tested in initial and advanced varietal trials of AICSIP in recent years, and three selections from an ICRISAT population based on M 35-2. There were 11 genotypes in the *rabi* 1998 trials and 22 in the *rabi* 1999 trials. These included the following:

- five recently released cultivars: variety CSV 14R, GRS 1 (DVS 4), 9-13 (DVS 5), Sel.3, and a hybrid (CSH 15R)
- three elite genotypes from AICSIP advanced varietal trials: SPV 1155, SPV 1359, and SPV 1380
- six from AICSIP initial varietal trials: RSLG 262, SPV 1360, SPV 1375, SPV 1411, SPV 1428, and SPV 1429
- four genotypes tested earlier: SPV 655, SPV 1215, SPV 1217, and GSS 2
- three population bulks derived from M 35-1: BLK 1, BLK 2, and BLK 3
- the popularly grown cultivar, M 35-1

Five genotypes—CSV 14R, CSH 15R, SPV 1359, SPV 1375 and M 35-1—were uniformly tested by all six NGO groups, but others were tested selectively by from one to five NGO groups, depending on previous experience. Varieties for which farmers could maintain the seed themselves were preferred over hybrids.

Trial design

Each of the six NGOs selected three villages, each with six participating farmers. The number of varieties tested by each NGO ranged from 10 to 12. The NGOs, in consultation with farmers, had decided to give each farmer 2 kg seed of each entry for advanced varietal trials and 1 kg seed of each entry for initial varietal trials. However, involving more farmers by providing each of them with less seed was considered a more appropriate design. Each genotype was tested by three farmers to

represent three replications. A trial consisted of growing the new cultivar alongside the local cultivar in a similar-sized plot without any plant protection and under farmer management. Observations on grain yield, dry fodder yield, grain appearance, and farmer-preferred traits (for male and female farmers) were recorded by skilled helpers. Farm walks, focus-group discussions, and house-level questionnaires were employed.

Results

Studies undertaken during *rabi* 1988 revealed that farmers' practices varied greatly. In most places, varieties were grown under rainfed conditions, but some farmers provided a single irrigation, and nitrogen applications varied from 0–100 kg urea per acre.

At Dhulia center, farmers planted deep behind the plough with no fertilizer and no pesticides. At Parbhani, farmers used four to five cart loads of farmyard manure and two 50-kg bags of 20:20:0 compound fertilizer per hectare. At Solapur center, the crop was planted in shallow soil, and 100 kg urea per acre was applied under irrigation, but other farmers did not apply fertilizer under rainfed conditions. At Bijapur, farmers applied 25 kg urea + 25 kg di-ammonium phosphate (DAP) per acre.

In 1998 in Maharashtra, SPV 1359 and SPV 1155 were often preferred by farmers over the local cultivar M35-1. At some locations, other varieties, such as SPV 1380 and the ICRISAT bulk derived from M35-1, were also preferred over M35-1. Local germplasm selections, such as RSLG 2623, were preferred at locations outside of their location of origin. This led us to test the local germplasm in all participating centers in 1999.

For 1999, although the genotypes were tested by all the NGO groups, only the data from Solapur are presented in detail (table 1). In six trials, SPV 1359 was found most productive with 3.7 t ha^{-1} grain yield, compared to 1.7 t ha^{-1} grain yield of the local cultivar. Thus, the grain yield of SPV 1359 in farmer-managed trials was more than double that of the local cultivar. There were more trials of SPV 1380 and CSH 15R; both gave almost double the grain and fodder yields of the local cultivar (table 1). M 35-1 was also tested against the locally grown landraces. In 16 such comparisons, its grain yield was 2.4 t ha^{-1} (compared to 1.5 t ha^{-1} for the local checks), an increase of 66%. The increases over locally grown cultivars are summarized in table 2.

Genotypes tested in the initial varietal trial also performed well (table 3). The cultivar SPV 655, earlier dropped from coordinated trials, gave the highest grain yield, 3.2 t ha^{-1} against only 1.3 t ha^{-1} of the farmer-grown local cultivar, an increase of 146%, and its fodder yield was double that of the local variety. The grain and fodder yield of SPV 1413 was also double that of the local variety grown by farmers. Two other genotypes, RSLG 262 and SPV 1411, gave more than 1.5 times the grain and fodder yields of the local varieties grown by farmers. These genotypes will be tested in 2000-2001 in more trials.

Farmers' perceptions of the improved genotypes

During 1998, farmers in general were satisfied with the grain yield of the new varieties, compared to their local cultivar, and demanded more seed from the new varieties. The popularly grown variety M 35-1 was not liked at certain places because of its side tillers. Women preferred bold and pearly seed, medium plant height (since this was convenient for harvesting the heads), higher flour

Table 1. Grain and Fodder Yields of Improved Genotypes in Farmers' Fields in Advanced Varietal Testing, *Rabi* Season, 1999, Solapur, India

		Grain yield (t ha-1)		Fodder yield (t ha-1)	
Entry	No. of trials	Improved	Local	Improved	Local
SPV 1359	6	3.7	1.7	4.5	3.0
SPV 1380	40	2.8	1.4	6.0	3.0
SPV 1155	2	2.4	1.8	5.2	4.1
M 35-1	16	2.4	1.5	5.4	2.9
CSH 15R	25	2.3	1.1	6.0	2.9

Table 2. Percent Increase of Improved Genotypes over Farmer-Grown Local Cultivar in Farmers' Fields in Advanced Varietal Testing, *Rabi* Season, 1999, Solapur, India

	Grain yield		Percentage of trials	Fodder yield	
Entry	(%) of local	Range	with >20% increase	(%) of local	Range
SPV 1359	116	7–195	67	32	(-)20–87
SPV 1380	96	4–194	88	113	20–244
M 35-1	66	(-)36–287	56	89	(-)14–382
CSH 15R	101	(-)7–228	88	105	(-)17–276

Table 3. Cultivar Performance in Farmers' Fields in Initial Varietal Testing, *Rabi* Season, 1999, Solapur, India

		Grain yield (t ha^{-1})		Increase	Fodder yield (t ha^{-1})		Increase over
Entry	No. of trials	Improved	Local	over local (%)	Improved	Local	local (%)
RSLG 262	3	2.5	1.5	69	5.6	3.8	47
SPV1462	5	1.6	1.4	14	6.3	5.3	20
BRJ 356	3	2.1	1.6	29	4.3	3.1	40
SPV 1413	5	2.5	1.2	109	6.0	2.8	117
SPV 655	15	3.2	1.3	146	6.6	3.2	109
SPV 1411	15	3.0	1.7	72	6.4	4.0	57
M 35-1 (B-3)	1	1.6	—	—	3.8	—	—

recovery (9:1), better cooking quality (good dough), soft and good tasting *chapatti*, and a longer storage life of the flour.

During *rabi* 1999 at Solapur, farmers reported on the high grain yield and good fodder quality of the improved cultivar SPV 1155 compared to M 35-1. Farmers said that SPV 1359 was excellent for its higher grain yield and bold grain but that it had no sweetness in the stem and thus its fodder was not preferred. In the case of SPV 1380, farmers' reactions were that it had excellent grain yield, bold grain, and loose panicles that helped stop birds sitting on them to eat the grain. However, they reported that it had poor-quality fodder because of a longer internodal length and leaf fall.

For the hybrid CSH 15R, farmers reported that it was good for high grain yield under irrigation, that it was earlier in maturity than the local cultivar, and that its fodder was moderately preferred. They were unhappy with the 60% to 70% grain filling that reduced its yield.

Conclusions

Participatory varietal selection appears to be an effective approach to supplement plant-breeding efforts in marginal areas, where progress with varietal adoption has been slow. It enables farmer-preferred varieties to be identified and tests the rigor of the varietal-testing program in multi-environment coordinated trials. In contrast to the general belief that M 35-1 is a popularly grown variety, access to NGOs and farmers revealed that various landraces are still grown in the Solapur area in addition to M 35-1. Improved varieties such as SPV 1359, SPV 1380, and SPV 1155 from the AICSIP advanced varietal trials, and SPV 655, a rejected genotype from the ACISIP trials, performed excellently. The first two have already been identified for release. Thus, the varietal testing at the research station is usually, but not always, satisfactory to determine adaptability under realistic farmer management. Further PVS success will depend on newly evolved varieties, based on the farmers' perceptions learned in these studies.

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The Impact of Participatory Plant Breeding (PPB) on Landrace Diversity: A Case Study for High-Altitude Rice in Nepal

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Abstract

Participatory plant-breeding (PPB) methods were used to develop two acceptable, cold-tolerant rice varieties in Nepal: Machhapuchhre-3 (M-3) and Machhapuchhre-9 (M-9). Both were derived from the cross Fuji 102/Chhomrong Dhan. Following the introduction of these varieties from 1993 to 1998, the changes in the rice landraces and varieties that farmers grew were studied in 10 villages. In seven of the villages, for which data were analyzed for both 1996 and 1999, farmers grew 19 landraces and four modern varieties, of which three (M-3, M-9, and Lumle 2) were the products of PPB. These three varieties covered 11% of the total surveyed area in 1999. The introduction of the PPB varieties had the greatest impact on the more commonly grown landraces. During the years studied, because the new varieties had exotic germplasm in their parentage, there was an overall increase in varietal diversity. However, in the future, increasing adoption of M-3 and M-9 could result in significant reductions in varietal diversity.

Introduction

Participatory plant breeding (PPB) is increasingly being used for decentralized crop improvement (Weltzein et al. 2000; Eyzaguirre and Iwanaga 1996; Sthapit, Joshi, and Witcombe 1996; Witcombe et al. 1996). Important elements of PPB commonly include the use in the breeding program of a local landrace or locally adopted variety as a parent, the screening of segregating materials in the target environment, and the participation of farmers in goal setting, selection, and evaluation.

Farmers in the hills and mountains of Nepal continue to grow landraces because centralized plant breeding has had limited success in producing varieties that farmers wish to adopt. The use of decentralized, participatory methods could remove this constraint to the adoption of new varieties. However, the products of PPB, if highly preferred by farmers, could have a considerable impact on local agrobiodiversity. In recent years, there has been a growing awareness of the value and utility of agrobiodiversity, and local nongovernmental organizations (NGOs) and international organizations are concerned about the conservation and utilization of biodiversity. For example, during the third global meeting of the International Plant Genetic Resources Institute (IPGRI), in July 1999, Pokhara, Nepal, the in situ crop conservation project of Dr. Ramnath Rao of IPGRI presented one possible impact that PPB products could have on landrace diversity (figure 1).

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