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.

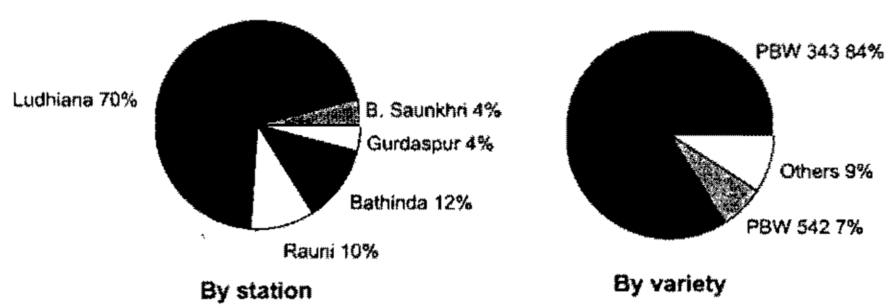
Methods

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

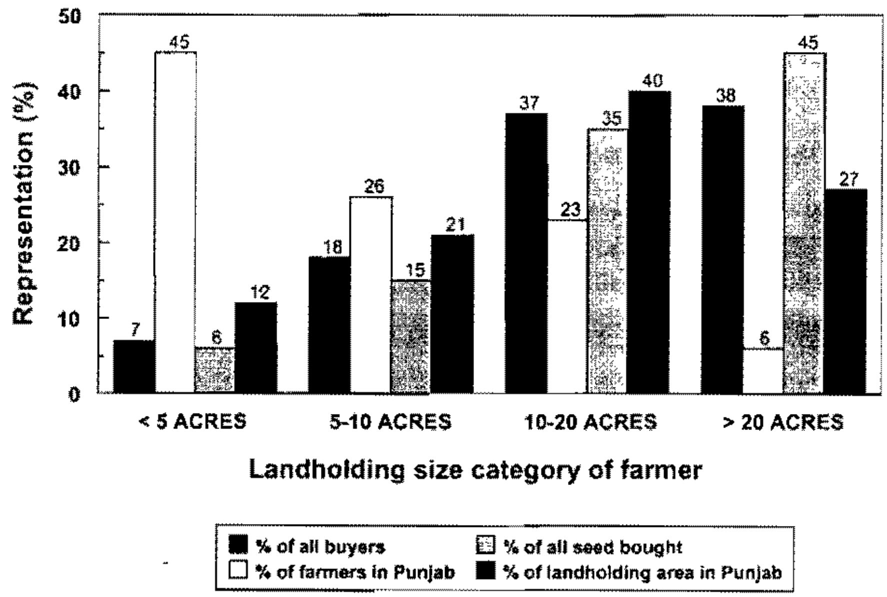


Figure 2. Wheat-seed sales by PAU at its main campus and four regional research stations, categorized by landholding size
(Sales by number of purchases and quantity of seed purchased are compared to the number of farmers and the area of land in the state by the landholding categories. The data presented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

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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 over local	Fodder yield (t ha^{-1})		Increase over local
Entry	No. of trials	Improved	Local	(%)	Improved	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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Machhapuchhre-3 and Machhapuchhre-9 are the products of the Agricultural Research Station, Lumle, Nepal Agricultural Research Council.

We acknowledge the contribution of all the farmers who collaborated in the initial PPB and in the spread of M-3 and M-9. The fieldwork by B. B. Paudel, community organizer of LI-BIRD is appreciated.

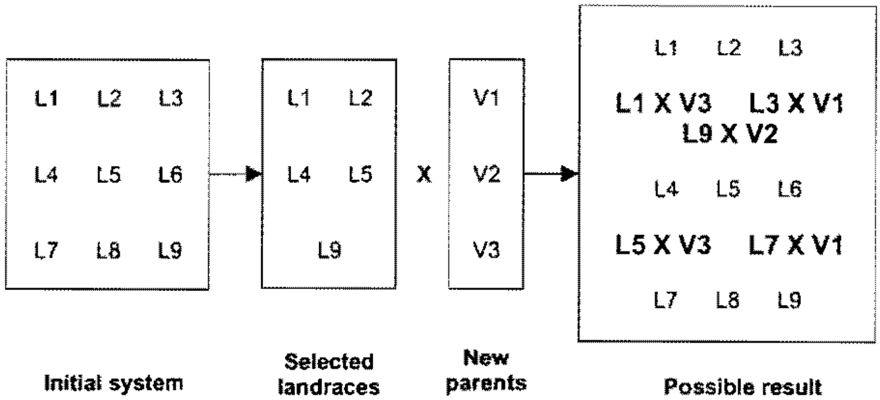


Figure 1. The impact of PPB products on local agrobiodiversity (In this scenario biodiversity is increased because it is assumed that none of the landrace are entirely replaced by new varieties produced by PPB.)

Materials and methods

Participatory plant breeding of high-altitude rice was initiated in 1993 by the Lumle Agricultural Research Centre (LARC) in the villages of Chhomrong and Ghandruk, both at an altitude of 2000 m, in the Kaski district of Nepal. Eighteen farmers collaborated in selecting between, and sometimes within, 10 F_5 bulk lines derived from three different crosses made by the Agricultural Botany Division of the Nepal Agricultural Research Council (Sthapit, Joshi, and Witcombe 1996). As a result of this program, in June 1996, the Variety Release and Registration Committee (VRRC) of Nepal made the first release of a variety produced with the extensive use of participatory methods: Machhapuchhre-3 (M-3) (Joshi et al., 1996). In a participatory varietal selection (PVS) program, farmers at Chhomrong also identified Machhapuchhre-9 (M-9), a sister line to M-3, as an acceptable variety. Starting in 1996, M-3 and M-9 were introduced into villages situated between 1200 m and 2300 m altitude by NGOs such as the Local Initiatives for Biodiversity Research and Development (LI-BIRD), CARE Nepal, the Annapurna Conservation Area Project (ACAP), and LARC.

The adoption and spread of M-3 and M-9 were monitored from 1996 to 1999. Five villages were surveyed in both 1996 and 1997, and 10 in both 1998 and 1999. Only the surveys in 1999 are reported here (table 1). Information was collected from the surveyed households using semi-structured interviews. Sampling was purposive (only from households known to have been given seed of M-3 or M-9). In 1998, farmers were asked about their adoption intentions to assess the possible impact of PPB products on the diversity of rice landraces. The 1999 survey, which covered about 18% of the households that had adopted and grown PPB products within the last three years (table 1), also collected information on the landraces farmers grew in 1996. For each household, the total area of *khet* land (irrigated and bounded terraces of land where rice is grown) was determined from the land-ownership certificates, and a total inventory of rice varieties, with the area that each variety occupied, was compiled.

The rice varieties and landraces were analyzed by the area in which they were grown and the number of households that grew them. Changes between 1996 and 1999 were assessed for area and household number for the more common landraces. The statistical significance of changes in area was determined by a two-tailed paired t test between the areas reported for 1996 and 1999.

Table 1. The Study Villages, 1999

Village	District	Altitude and aspect	Households: in the village	in 1999 survey	with data for 1996
Chhomrong –Ghandruk	Kaski	1800-2000, NE	55	12	12
Chane-Kimche, Landruk-Tolka	Kaski	1500-1900, SW	142	14	14
Marangche	Kaski	1400-1600, SE	34	30	30
Kande	Kaski	1400-1600, N	55	11	11
Khanigaun, Lwang	Kaski	1600-1900, SE	68	11	0
Patlikhet	Myagdi	1400-1700, SW	50	6	6
Bhakimle	Myagdi	1600-2300, N	181	16	16
Chipleti	Myagdi	1400-1800, S	78	11	11
Bangsing Deurali	Syangja	1300-1500, S	64	6	0
Bangephadke.	Syangja	1400-1600, S	28	10	0
Total		—	754	127	100

Results and discussion

Adoption of M-3 and M-9 in 1999

M-3 was introduced to all 10 study villages and was adopted in all of them, while M-9 was introduced to seven of the villages but was adopted in three (figure 2). The most important factors in determining adoption were the altitudes of the villages and the year in which they first received seed. Apart from the low-altitude village of Bangephadke, adoption of either M-3 or M-9 was at least 10% of the rice area in villages that had received seed before 1998.

Impact of M-3 and M-9 on varietal richness

Since the ancestors of the landraces were not known, no analysis of diversity could be done that required a knowledge of the relatedness of the cultivars with each other. However, richness can be assessed by the number of landraces and varieties grown (figure 3) for the seven villages for which there were data for both 1999 and 1996. The total number of rice cultivars decreased little in the study villages. This was despite the adoption of varieties produced by PPB that might have been expected to have replaced several of the landraces. The number of rice cultivars grown in 1999 increased in two of the study villages and decreased in two, while in three of the villages there was no change (figure 3).

The decrease in diversity in Chhomrong and Ghandruk is not surprising since the initial PPB program was conducted in these villages. In the early stages, as many as nine lines were grown in 1996 at Chhomrong alone, but by 1999, the undesirable lines had been dropped. Another case of decrease was in Chane and Kimche, where adopting households dropped the Tairige and Takmare landraces to grow M-3 even though M-3 covered less than 15% of the total rice area.

In all of the seven study villages, some of the rice area that was under landraces in 1996 was occupied in 1999 by M-3 and M-9. This increased genetic diversity, since M-3 and M-9 have exotic germplasm in their ancestry. M-3, M-9, and Lumle-2 all have a local landrace, Chhomrong Dhan, as a parent. Fuji 102, an exotic variety from Japan, is a parent of M-3 and M-9, and IR36, an

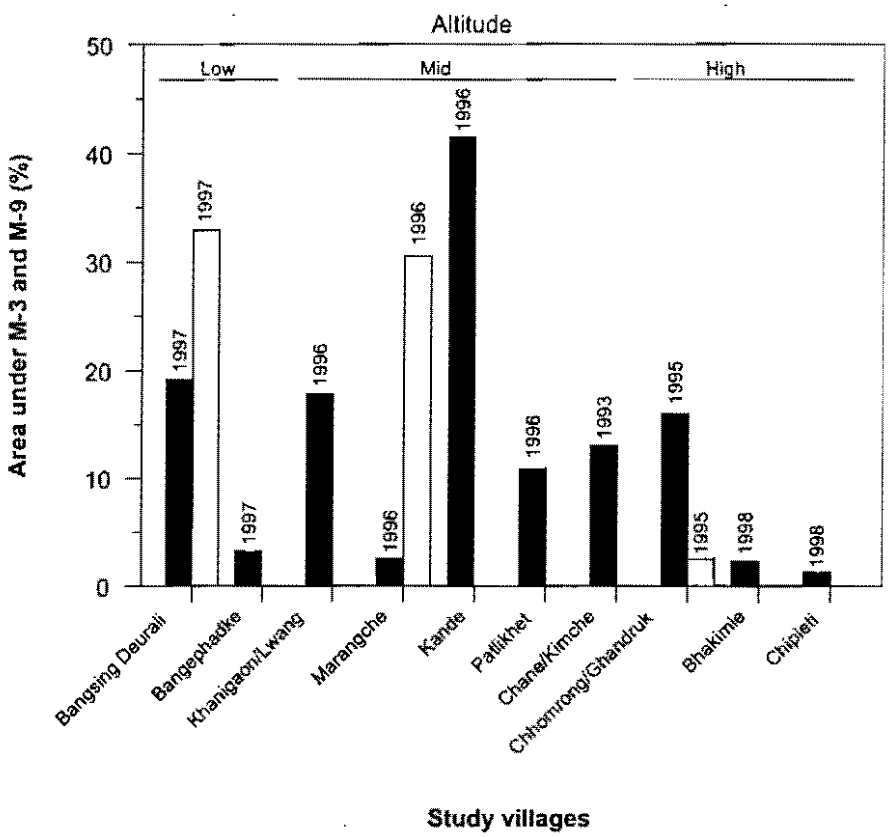


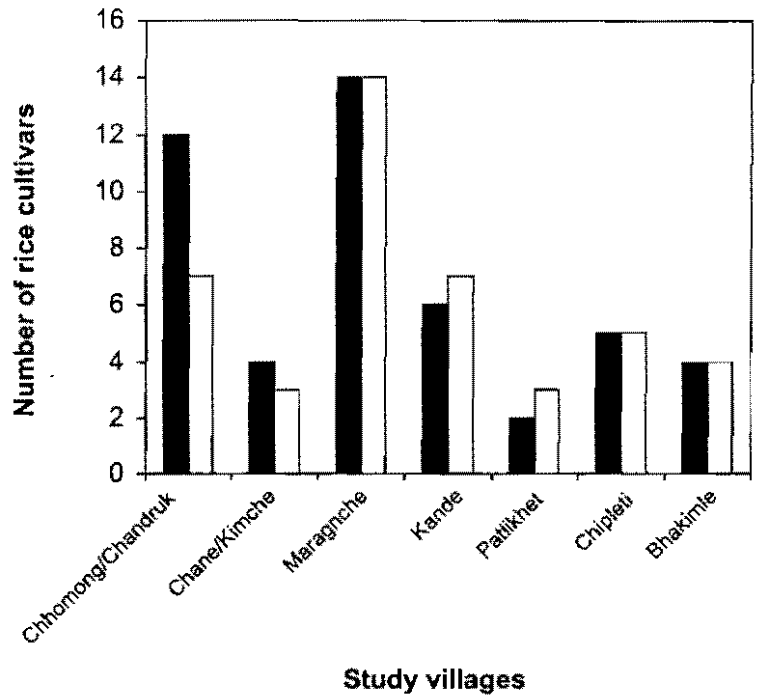
Figure 2. Adoption in 1999 of Machhapuchhre-3 (solid bars) and Machhapuchhre-9 (open bars) in 104 sampled households in the 10 study villages (The year of first introduction of M-3 or M-9 is indicated above the bars.)

International Rice Research Institute (IRRI) variety, is a parent of Lumle-2. Chhomrong Dhan was grown in only three of the seven villages, so in four of them, there was no cultivar that was genetically related to the PPB products.

Classification of landraces by their relative abundance

In 1999, farmers grew 19 landraces and five modern varieties in the seven study villages for which both 1996 and 1999 data were available. Of the five modern varieties, three were the products of PPB (M-3, M-9, and Lumle-2). The average area devoted to any landrace by the households in the study villages was quite small (<0.3 ha) (figure 4). Of the 19 landraces in these seven villages, 12 were reasonably common (figure 4). Of the seven less common, five were grown by only one of the sampled households and two had a combination of low household number and a small average area.

While studying the occurrence and diversity of local landraces in Kaski (a low to mid-hill site, 750 m to 1300 m) and Bara (100 m to 150 m), Joshi et al. (1999) found that only a few landraces were widely grown. The great majority of landraces or varieties were less common and had either a small area or few households growing them, or both. A similar result was found for *ghaiya* (upland rice) landraces (Joshi et al., forthcoming). This was also found for modern varieties in the Nepal *Terai* (Joshi and Witcombe, this volume).



Note: Open bars = 1996; solid bars = 1999.

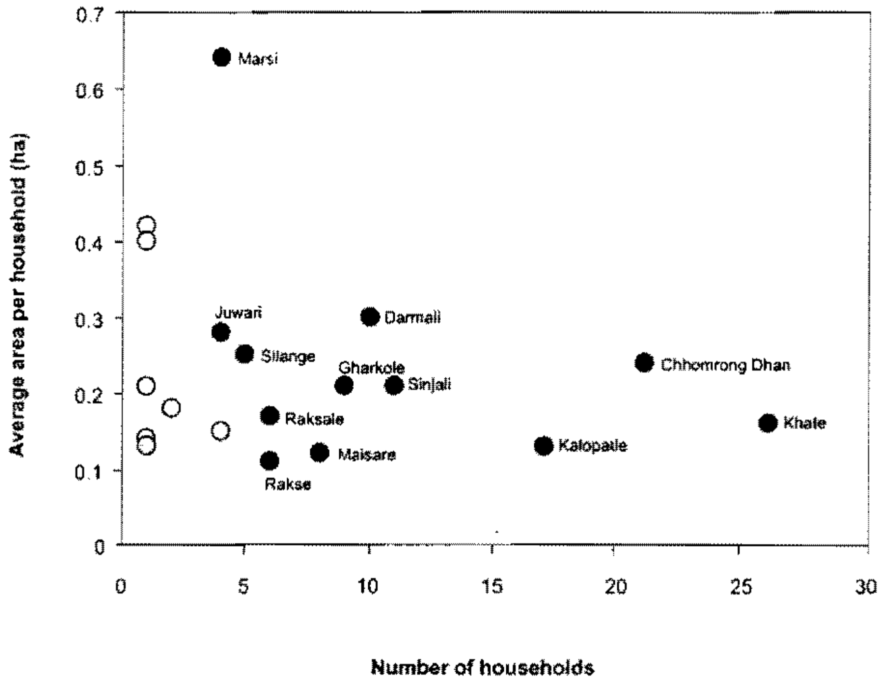
Impact of M-3 and M-9 on landrace diversity

Farmers' perceptions in 1998. In 1998, farmers' perceptions of the impact that PPB products would have on local landrace diversity were recorded. Most of the respondents reported that they would increase the area under M-3 or M-9. About 24% of the respondents reported that the adoption of M-3 or M-9 would either reduce the area under landrace Kathe or entirely replace it. A similar situation was perceived for landraces Kalopatle (8% of respondents), Maisara (6%), Raksali (3%) and Darmali (3%). A further 10% of the surveyed households also mentioned the possible partial replacement of 10 other landraces and one modern variety. No households reported that they would entirely replace the landrace Chhomrong Dhan or the modern variety Khumal-4, even though at least one household mentioned the complete replacement of at least one of the remaining 19 landraces.

Results of the 1999 survey

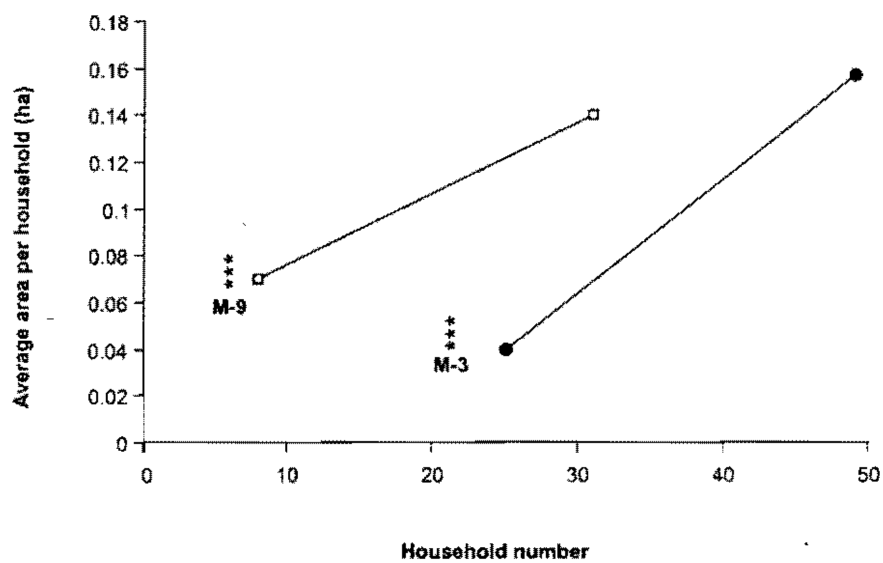
The 1999 survey confirmed most of the 1998 perceptions. The area and number of adopting households increased significantly for M-3 and M-9 (figure 5). The increasing adoption of M-3 and M-9 is likely to have far greater impact on landrace diversity in the future than what had already taken place by 1999.

In 1999, the area under 12 out of the 19 landraces had decreased, while for eight of them, the number of adopting households decreased. Area was more dynamic than the number of households probably because a decision to change the area under a landrace is more common than to entirely drop a landrace or adopt a new one.



Note: The more common landraces are marked with solid circles and labeled with names. Tthe less common landraces are marked with grey circles and are Phake Dhan, Gunta, Pahenle, Rakse, Maisare, Takmare, Galaiya, Tarkaya and Anga.

Figure 4. Landrace frequency by number of adopting households and average area grown by each household in 1999 in the seven villages for which 1996 and 1999 data were available (see table 1)



Note: Lines are labeled next to the 1996 origin of the line. Both cultivars have significant changes in area (*** = $p \leq .001$). The significance of changes in adopting households was not tested.

Figure 5 Change in area and household adopters from 1996 to 1999 for M-3 and M-9 in seven villages (see table 1)