Addressing genetic improvement and on-farm diversity through farmer participatory breeding: A case study of rainfed rice in the Faizabad and Siddharthnagar districts, Eastern Uttar Pradesh, India

ON SINGH[1], S SINGH[1], VN SINGH[1], JL DWIVEDI[1], A SINGH[1], HN SINGH[1], RK SINGH[2], TR PARIS[3], GN ATLIN[3] AND VP SINGH[3]

1. NDUAT, Kumarganj, Faizabad, India.
2. IRRI-India Office, NASC Complex, Pusa, New Delhi, India.
3. IRRI, DAPO, Box 7777, Metro Manila, Philippines.

Abstract

Resource-poor farmers in Uttar Pradesh, India, face a number of production constraints to rainfed rice growing, ranging from poor performance of traditional varieties and a lack of access to new ones, to unpredictable weather. A farmer participatory breeding programme begun in 1997 sought to address those problems by developing new rice genotypes.

During the four years of the study, several important points were established: Farmers could visually rate for yield with high accuracy, and their visual yield ratings were the best predictor of farmer preference. Some cultivars produced very high yields under low-input management, and were highly preferred by farmers. However, some high yielding varieties were not preferred, while some farmers preferred varieties that did not give a high yield.

Introduction

In Uttar Pradesh rice is grown in 5.5 million ha, of which 2.2. million ha (40%) of rice lands are rainfed lowland and 0.7 million ha are upland (13%). The impact of the Green Revolution is hardly visible in such areas due to several factors:

- Poor and inconsistent performance of on-station developed varieties when grown under farmers' management;
- An inability to meet farmers' preferences for quality;
- A lack of information about new varieties or poor access to seeds of them, or both information and seed are lacking.

The major production constraints in rainfed rice include an unpredictable combination of droughts and floods, build-up of pests and diseases, poor physical soil conditions and socioeconomic limitations. Farmers are resource poor, which limits their risk-management strategies in rice cultivation. Therefore, the development of rice varieties suitable for these fragile ecologies will make a positive impact on the millions of poor people whose livelihoods depend on them.

Narendra Deva University of Agriculture and Technology (NDUAT) in Faizabad, eastern India, in collaboration with IRRI, initiated a farmer participatory breeding (FPB) programme in 1997. In this approach, the needs and priorities of farmers were taken into account during the early evaluation of rice genotypes, both on the station and on farmers' fields.

This paper discusses the FPB approach and its impact on on-farm diversity conservation by the participating farmers.

Methodology

Three typical rainfed sites were chosen - Sariyawan and Mungeshpur in Faizabad, and Basalatpur in Siddharthnagar districts. Basalatpur represented a favourable lowland environment, while Mungeshpur and Sariyawan represented shallow but submergence- and drought-prone areas.

Three approaches were followed:

Participatory plant breeding (PPB)

This included F4 generations of six different crosses involving diverse parents. These segregating populations were jointly assessed by farmers and breeders on-station as well as on farmers' fields. Two breeders and five farmers selected separately from F4 to F6 during the 1997, 1998 and 1999 cropping seasons. Altogether, 50 populations were developed and tested in three replications on-station and in two replications on-farm. From these, six lines for Faizabad and five lines for Siddharthnagar conditions - identified by breeders, farmers or both - were selected and compared in field trials. Observations were recorded on traits such as yield.

Participatory varietal selection (PVS)

This was initiated during the rainy season of 1997 and continued in the 1998 rainy season. Fifteen to 20 entries were tested on-station and on farmers' fields. The entries included advanced breeding lines from the IRRI-led Shuttle Breeding project, released varieties, and the most common local varieties. Two farmers each from the village of Mungeshpur (drought prone), Sariyawan (drought and submergence prone), Faizabad and Basalatpur (submergence prone), and Siddharthnagar were chosen for PVS experiments. Final PVS trials were conducted during 2001, both on-station and on-farm in Faizabad district.

Mother-Baby PVS programme

This was initiated during the wet season of 2001, and consisted of replicated researcher-managed mother trials with 15 genotypes at Masodha rice research station, Faizabad. In these experiments recommended fertilizer doses were used.

Nine farmers in Siddharthanagar district conducted the baby trials in three villages. Each baby trial included five genotypes and were entirely managed by farmers. The alfa-lattice incomplete-block design was used for the layout and analysis of the baby trials. Simple rating scales (1-5) for different characteristics were used for statistical analysis. A simple form was used to elicit additional information from the farmers on the traits and to get suggestions on how to improve the trials.

Important findings of PPB and PVS

PPB

With few exceptions, the genotypes flowered earlier on farmers' fields than on-station. However, yields on farmers' fields were generally lower, as the genotypes suffered prolonged waterlogging, particularly at Siddharthnagar. While a coarse grain type (IR 700803-43-NDR-2-9335) selected by the farmers performed best both on-farm and on-station at Faizabad, the farmers in Siddharthnagar preferred an early type (123 day duration) that showed a maximum yield of 5.1 t ha^{-1} on station fields and 3.2 t ha^{-1} on farmers' fields.

PVS

Ten farmers (five women and five men) visited individual plots and ranked the genotypes grown on different farmers' fields. Farmers' selection criteria were based on ecological needs, livelihood uses, gender and social and economic background. Mungeshpur and Sariyawan farmers preferred genotypes with drought tolerance and short-medium maturity. In contrast, Basalatpur farmers selected slightly late-maturing genotypes with submergence tolerance and long, slender grains. In general, rice grain yields observed on farms were lower than on-station. However, some of the cultivars produced very high yields (> 4 t ha^{-1} under low-input management) and were highly preferred by farmers.

Farmers did select more than one variety (eight in this case), indicating that PVS/PPB can help maintain varietal diversity on-farm. Traits such as threshability, submergence tolerance, and grain shape were also preferred in this set of cultivars. Straw traits, and pest and disease resistance ratings were not selected by farmers. Data for grain yield collected from the on-farm trials were highly repeatable.

Mother-Baby PVS trials

Significant differences were observed for grain yield among the genotypes tested in the mother trials. However, there was little difference in yield and its attributes between the two treatments. Farmers perceived significant differences between the cultivars for grain yield, submergence tolerance, threshability (particularly women farmers), grain shape and overall acceptability.

Differences in measured grain yield were highly significant. The reliability of yield measurements was much higher than expected for on-farm trials. Two of the highest-yielding genotypes gave over 4 t ha^{-1} on-farm, and were highly preferred by farmers over their own varieties. However, one high-yielding genotype was not preferred, but no clear reason for this anomaly could be determined from the questionnaire results.

On a single-plot basis, farmer visual yield ratings were highly correlated with measured yield (r = 0.84) (Table 1). Farmer yield rating and farmers' preference rating were also highly correlated (0.75). Breeder preference rating was highly correlated with measured yield (-0.81) and farmers' yield rating (0.94).

On a genotype mean basis, farmers' yield rating and measured yields were highly correlated (0.90). Farmers had a strong preference for cultivars they rated highly for yield (r = 0.81) (Table 2).

On-farm diffusion and varietal diversity

While PVS trials continued, farmers picked up a few

Table 1. Correlations among plot values for measurements and ratings taken by farmers and breeders in baby trials in three villages in Siddarthnagar (rainy season, 2001).

	Grain yield	Farmer preference	Breeder preference	Farmer yield	Farmer submergence tolerance	Farmer threshability
Grain yield	-0.59	-0.81	-0.84	-0.53	-0.69	-0.46
Farmer preference		0.75	0.74	0.48	0.61	0.59
Breeder preference			0.94	0.49	0.69	0.6
Farmer yield				0.49	0.74	0.62
Farmer submergence tolerance					0.34	0.45
Farmer threshability						0.33

Table 2. Correlations among cultivar means for measurements and ratings taken by farmers and breeders in baby trials in three villages in Siddharthnagar (Kharif 2001).

	Grain yield	Farmer preference	Breeder preference	Farmer yield	Farmer submergence tolerance	Farmer threshability
Grain yield	-0.67	-0.87	-0.90	-0.61	-0.89	-0.57
Farmer preference		0.80	0.81	0.69	0.77	0.75
Breeder preference			0.96	0.74	0.83	0.74
Farmer yield				0.70	0.84	0.75
Farmer submergence tolerance					0.70	0.75
Farmer threshability						0.53

lines that they found promising and grew them on larger plots. For example, three genotypes, PVS1, 7 and 10, were grown in two villages of Faizabad district on 23 farmers' fields in 2000, and 36 fields in 2001. Similarly, six genotypes, PVS 1, 2, 3, 7, 10 and 13 were cultivated on 45 farmers' fields in 2000, and 48 fields in 2001, covering seven villages in Siddharthnagar district (Table 3). This clearly indicates that FPB not only enriches the existing diversity of rice varieties grown under rainfed conditions, but also allows farmers to grow improved varieties they have chosen themselves.

Conclusions

- Farmers could visually rate for yield with high accuracy.
- Farmer visual yield ratings were the best predictor of farmer preference.
- Some preferred varieties were not high yielding (e.g. NDRSB9830102, which gave 2.5-3.6 t ha^{-1}), and some high yielders, such as NDR 40032 (3.2-4.1 t ha^{-1}) and NDRSB 9730020 (4.2-5.8 t ha^{-1}) were not preferred.
- Some cultivars produced very high yields (> 4 t ha^{-1}) under low-input management, and were highly preferred by farmers.
- Over the years of the study, farmers did not continue all the lines that they had selected in previous years. This was because they took into account additional information from

Table 3. On-farm diffusion of PVS lines, 1998-2001

Years and location	Designation	No. of farmers	Total area (ha)	Yield range (t ha^{-1})
2000				
Faizabad	NDR-40032	2	0.16	3.5-5.5
	NDRSB-9830102	18	2.17	2.8-3.7
	NDRSB-9730020	3	1.50	3.5-4.8
Siddharthnagar	NDRSB-9730004	9	1.00	1.8-2.5
	NDRSB-96005	6	1.15	2.4-4.2
	NDRSB-40032	8	0.80	3.5-5.2
	NDRSB-9730020*	12	2.85	3.7-5.6
	NDRSB-96012	3	0.38	2.5-3.6
	Kamini	6	0.85	1.6-2.5
	Sugandha	1	0.40	1.5-2.2
2001				
Faizabad	NDR-40032	4	0.56	3.2-4.1
	NDRSB-9830102	23	3.10	2.5-3.6
	NDRSB-9730020	9	1.18	4.2-5.8
Siddharthanagar	NDRSB-96005	5	0.90	3.4-4.7
	NDRSB-9730020	19	4.60	3.9-5.6
	NDR-40032	8	1.20	3.6-4.8
	Kamini	11	1.70	1.5-2.5
	NDRSB-9830102	5	0.95	2.6-3.5

*Spread in Nepal by relatives of cooperator farmer but not monitored

various trials and later observations (such as sensory evaluation, milling recovery, and drought incidence), in order to finally decide whether to select or reject a variety.