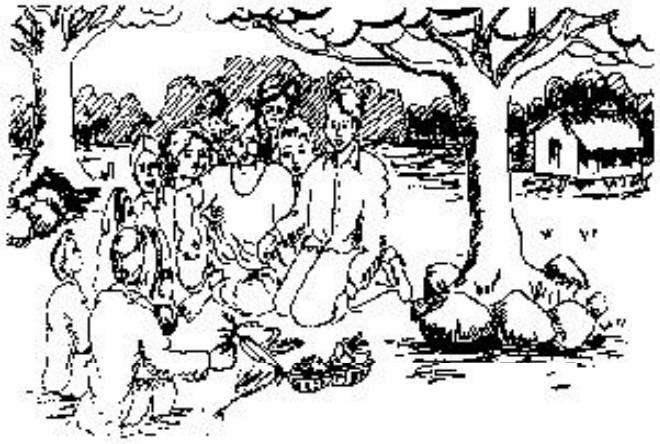
WIRFP Participatory Plant Breeding: Concepts and Examples



Gramin Vikas Trust is implementing the Western India Rainfed Farming Project, funded by the Department for International Development, United Kingdom; Government of India; State Governments and Krishak Bharati Cooperative Limited (KRIBHCO). The project is working for sustainable livelihood enhancement of poor women and men in highly risk-prone, tribal-dominated areas covering seven districts - namely Jhabua, Dhar and Ratlam (Madhya Pradesh) Banswara and Dungarpur (Rajasthan), Dahod and Panchmahals (Gujarat). This paper presents the results of collaborative research in participatory plant breeding with Gujarat, Rajasthan and Madhya Pradesh agricultural universities.

Introduction

The centralised plant breeding techniques of the green revolution have yielded good results in the more favourable agricultural environments. Most low-resource farmers in the marginal areas of the project, however, have not benefited from these varieties (Figure 1). As an alternative to centralised breeding, farmer participatory approaches - participatory plant breeding (PPB) - are being adopted in the Western India Rainfed Farming Project.

PPB is an extension of Participatory Varietal Selection (PVS) (see *WIRFP Farmer-managed Participatory Research for Varietal Selection*, May 2002). In PPB, farmers are actively involved in the breeding process, from setting goals to selecting variable, early-generation material. In PVS, farmers are given a wide range of new cultivars to test for themselves in their own fields. In our PPB programmes we have exploited the results of PVS by using identified cultivars as parents of crosses.

Figure 1. **Resource-poor farmers often have to grow crops in low-quality soils in drought-prone environments. Conventional plant beeding has generally failed to produce varieties for these harsh conditions.**

REGISTERED OFFICE : Chief Executive Officer, Gramin Vikas Trust, H.No. 79, Sec. 15A, Noida-201301, Distt. Gautambudh Nagar (U.P.)
Tel. : 0118 - 4513720, 4513721, 4513729, 4513723, Fax : 4513726 E-mail : honoida@gvtindia.org

PROJECT OFFICE : Project Manager, Gramin Vikas Trust, 1, Chitragupta Society, E-7, Arera Colony, Bhopal - 462013 (M.P.)
Tel. : 0755 (O) 420932, Fax : 0755 - 420292 E-mail : gvtbhopal@sify.com Website : www.gvtindia.net

May 2002

Key assumptions for PPB

- Farmers are interested in participating in plant breeding
- Farmers and scientists can successfully collaborate.
- It will not fail because:
  - the parents of crosses include locally adapted material;
  - selection is in the local environment;
  - varieties are selected by farmers for the traits farmers consider important.

Types of PPB

PPB can be **consultative** and **collaborative**. The approach used will depend on the crop and the availability of resources.

Consultative

Farmers are consulted at every stage - for example, in setting the breeding objectives, choosing the appropriate parent, and by making joint selections with breeders from material grown by breeders. Hence, until there is a finished product from the breeding programme for farmers to test in PVS trials, farmers are not involved in growing material in their fields.

Collaborative

Farmers grow the variable PPB material in their own fields and select the best plants from it. Scientists can then obtain seed from farmers to test their selections in research station and participatory trials.

What crosses to make?

PVS can be efficiently followed by PPB since farmer-preferred cultivars are the ideal parents for PPB programmes. Examples are:

- PVS cultivar x high-yielding variety.
- Local landrace x PVS cultivar.
- Local landrace x high-yielding variety.

Steps for participatory plant breeding

1. Set the breeding objectives
   - Crop-focused PRAs
   - Analyse results of participatory varietal selection.

2. Identify the parent material
   - From local landraces
   - From varieties tested by PVS
   - From high-yielding varieties with complementary characteristics.

3. Decide on the model (consultative/collaborative)
   - On the basis of available resources
   - On the basis of the crop (collaborative participation is simpler in an inbreeding crop).

4. Enter the best participatory plant breeding lines in PVS trials and facilitate their entry in formal on-station trials.

5. Prepare release proposal, if success is achieved.

When to use PPB?

- When no existing cultivars are identified that are suitable for testing in a PVS programme.
- When PVS has been tried but has failed to identify any varieties that farmers prefer.

Advantages of participatory over conventional breeding methods

- At least one parent in any cross is well adapted to the local environment.
- Genotype x environment interactions are used positively because breeding is done in the target environment.
- The impact of genotype x year interaction is probably reduced because local parental materials have adapted to local year-to-year variations.
- Only a few crosses are made, so large F_2 and F_3 populations can be grown to increase the likelihood of selecting desirable segregants.

A case study - PPB in maize

Maize is the most important rainy season cereal crop in the marginal, upland areas of the project. We gave maize farmers in Gujarat, Rajasthan and Madhya Pradesh new varieties to try in a PVS programme. These included white- and yellow-grain types.

The farmers did not markedly prefer any of our varieties to their local ones. However, some of the varieties had specific traits that the farmers wanted, so in a PPB programme we crossed six of them to produce a composite population. We made the initial selections from this population based on characteristics identified by farmers, and at later stages farmers selected for themselves in populations grown by us. Three of the most promising white-grain varieties produced from the population were then assessed in formal and participatory trials.

Outstanding new variety

GDRM-187 was one of these three promising varieties. It was bred as an extra-early maturity maize variety. When farmers tested it in PVS trials, they liked the qualities of GDRM-187. It was very popular and high yielding in their fields over two seasons (Figure 2).

This variety matures earlier than the earliest local varieties by about seven days. It produces fewer barren plants and larger cobs, which, unlike local varieties, are filled to the tip (Figure 3). Farmers also noticed that the husk completely and tightly enclosed the cobs, thus reducing insect attack.

Farmers greatly appreciated the grain quality of the variety. By using our PVS programme to identify suitable parents, by selecting for characteristics valued by the farmers and by testing under the farmers' own conditions, a new and improved variety acceptable to farmers was rapidly produced.

Figure 2. **A farmer inspects his crop of GDRM-187. This new variety is popular with farmers because it is extra-early and produces a high yield.**

Figure 3. **The maize variety GDRM-187 (right) has much larger, more uniform cobs than the local variety.**

PVS follows PPB

PVS follows seamlessly from PPB. As soon as potential varieties have been produced by PPB, farmers test them using PVS. This is an important advantage as the results of PPB reach farmers more quickly than the results of conventional breeding, where varieties are typically tested with farmers only after a long delay for on-station testing and multiplication (Table 1). Delay in obtaining benefits reduces the rate of return on the investment in plant breeding. The economic value of this reduction in time can be very large.

Table 1. **A comparison of the breeding of maize cultivar GDRM-187 by participatory methods and the conventional breeding of maize cultivar GM-4.**

	GDRM-187 (PPB)	GM-4 (Conventional)
Years from cross to year of first testing	4 1993-1997	6 1989-1995
Years from cross to farmers	4 1993-1997	12 1989-2001
Days to 50% silking	45	50
Yield gain over check (%)	37 (over GM-1)	21 (over GM-1)

There is often a trade-off between yield and early maturity. An early variety escapes common end-of-season droughts, and produces a harvest at the hungriest time of the year, before other crops mature. It also reaches the market first, so its grain fetches a higher price.

The DFID Plant Sciences Research Programme has collaborated with GVT-West and TC consultants in the work reported here and in the preparation of this document.

Possible Outcomes/Benefits of PPB

- *Production gains*: yield increases; increases in stability of yield; faster uptake; wider diffusion; and higher market value of products.
- *Biodiversity enhancement*: communities have wider access to germplasm; wider access to related knowledge; and increased inter- and intra-varietal diversity.
- *Cost-efficiencies and effectiveness*: fewer research dead-ends; more opportunities for cost-sharing in research; and less expensive means of diffusing varieties.
- *Effective meeting of user needs*: higher degree of farmer satisfaction; broader range of users reached, including marginal farmers; and promotion of group learning through farm walks.

Building on the success

The Western India Rainfed Farming Project now has probably the largest - certainly the most diverse - PPB programme of any development project. Collaborative arrangements for PPB programmes are in place with three universities* in Madhya Pradesh, Rajasthan and Gujarat. These programmes include six crops: maize, rice, horsegram, black gram, niger and sunn hemp. A big advantage of this multi-crop approach is that large gains can be expected from breeding neglected crops, such as horsegram. They can also be bred to fit better into local farming systems - current horsegram varieties mature too late to successfully intercrop with maize. In time, short-duration maize and horsegram varieties from the PPB will be grown together by farmers.

These collaborative PPB programmes follow the principles described in this paper, and products from PPB in rice and maize are already in advanced trials. Considering the impact that just one new variety can have on improving farmers' livelihoods, the potential impact of this collaborative programme is immense.

* Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Madya Pradesh; Maharana Pratap University of Agriculture and Technology Udaipur, (MPUATU), Rajasthan; and Gujarat Agricultural University (GAU).

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Madhukar Tower, Ramkrishna Colony, Sardar Patel Marg, Jhabua-457661 (M.P.) **Tel. : 07392-44289, 43555 Fax : 44324**
E-mail : jbagvt@bom6.sancharnet.in

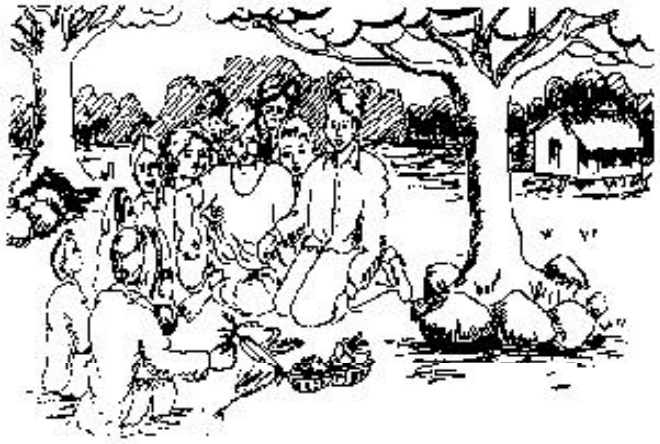
STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 44 Gulshan Bhawan, TIT Road, Ratlam-457001 (MP)
Tel. : 07412 - 20500, 33366, Fax : 33384 E-mail : gvtratlam@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 143, Taldar Building, Subhash Nagar, College Road, Banswara (Raj.) 327001, **Tel. : 02962-46888, 47888 Fax : 46889 Resi. : 48999**
E-mail : gvt_bsw@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Kanchan Kunj, Anand Bhawan Compound Chakaliya Road, Dahod-389151 (Gujarat), **Tel. : 02673-46984, 21311 Fax : 46392 Resi. : 46155**
E-mail : gvtdahod@ad1.sancharnet.in

SUNRISE PRINTERS, UDAIPUR Tel. : 0294-524780

WIRFP Participatory Plant Breeding: Concepts and Examples



Gramin Vikas Trust is implementing the Western India Rainfed Farming Project, funded by the Department for International Development, United Kingdom; Government of India; State Governments and Krishak Bharati Cooperative Limited (KRIBHCO). The project is working for sustainable livelihood enhancement of poor women and men in highly risk-prone, tribal-dominated areas covering seven districts - namely Jhabua, Dhar and Ratlam (Madhya Pradesh) Banswara and Dungarpur (Rajasthan), Dahod and Panchmahals (Gujarat). This paper presents the results of collaborative research in participatory plant breeding with Gujarat, Rajasthan and Madhya Pradesh agricultural universities.

Introduction

The centralised plant breeding techniques of the green revolution have yielded good results in the more favourable agricultural environments. Most low-resource farmers in the marginal areas of the project, however, have not benefited from these varieties (Figure 1). As an alternative to centralised breeding, farmer participatory approaches - participatory plant breeding (PPB) - are being adopted in the Western India Rainfed Farming Project.

PPB is an extension of Participatory Varietal Selection (PVS) (see *WIRFP Farmer-managed Participatory Research for Varietal Selection*, May 2002). In PPB, farmers are actively involved in the breeding process, from setting goals to selecting variable, early-generation material. In PVS, farmers are given a wide range of new cultivars to test for themselves in their own fields. In our PPB programmes we have exploited the results of PVS by using identified cultivars as parents of crosses.

Figure 1. **Resource-poor farmers often have to grow crops in low-quality soils in drought-prone environments. Conventional plant beeding has generally failed to produce varieties for these harsh conditions.**

REGISTERED OFFICE : Chief Executive Officer, Gramin Vikas Trust, H.No. 79, Sec. 15A, Noida-201301, Distt. Gautambudh Nagar (U.P.)
Tel. : 0118 - 4513720, 4513721, 4513729, 4513723, Fax : 4513726 E-mail : honoida@gvtindia.org

PROJECT OFFICE : Project Manager, Gramin Vikas Trust, 1, Chitragupta Society, E-7, Arera Colony, Bhopal - 462013 (M.P.)
Tel. : 0755 (O) 420932, Fax : 0755 - 420292 E-mail : gvtbhopal@sify.com Website : www.gvtindia.net

May 2002

Key assumptions for PPB

- Farmers are interested in participating in plant breeding
- Farmers and scientists can successfully collaborate.
- It will not fail because:
  - the parents of crosses include locally adapted material;
  - selection is in the local environment;
  - varieties are selected by farmers for the traits farmers consider important.

Types of PPB

PPB can be **consultative** and **collaborative**. The approach used will depend on the crop and the availability of resources.

Consultative

Farmers are consulted at every stage - for example, in setting the breeding objectives, choosing the appropriate parent, and by making joint selections with breeders from material grown by breeders. Hence, until there is a finished product from the breeding programme for farmers to test in PVS trials, farmers are not involved in growing material in their fields.

Collaborative

Farmers grow the variable PPB material in their own fields and select the best plants from it. Scientists can then obtain seed from farmers to test their selections in research station and participatory trials.

What crosses to make?

PVS can be efficiently followed by PPB since farmer-preferred cultivars are the ideal parents for PPB programmes. Examples are:

- PVS cultivar x high-yielding variety.
- Local landrace x PVS cultivar.
- Local landrace x high-yielding variety.

Steps for participatory plant breeding

1. Set the breeding objectives
   - Crop-focused PRAs
   - Analyse results of participatory varietal selection.

2. Identify the parent material
   - From local landraces
   - From varieties tested by PVS
   - From high-yielding varieties with complementary characteristics.

3. Decide on the model (consultative/collaborative)
   - On the basis of available resources
   - On the basis of the crop (collaborative participation is simpler in an inbreeding crop).

4. Enter the best participatory plant breeding lines in PVS trials and facilitate their entry in formal on-station trials.

5. Prepare release proposal, if success is achieved.

When to use PPB?

- When no existing cultivars are identified that are suitable for testing in a PVS programme.
- When PVS has been tried but has failed to identify any varieties that farmers prefer.

Advantages of participatory over conventional breeding methods

- At least one parent in any cross is well adapted to the local environment.
- Genotype x environment interactions are used positively because breeding is done in the target environment.
- The impact of genotype x year interaction is probably reduced because local parental materials have adapted to local year-to-year variations.
- Only a few crosses are made, so large F_2 and F_3 populations can be grown to increase the likelihood of selecting desirable segregants.

A case study - PPB in maize

Maize is the most important rainy season cereal crop in the marginal, upland areas of the project. We gave maize farmers in Gujarat, Rajasthan and Madhya Pradesh new varieties to try in a PVS programme. These included white- and yellow-grain types.

The farmers did not markedly prefer any of our varieties to their local ones. However, some of the varieties had specific traits that the farmers wanted, so in a PPB programme we crossed six of them to produce a composite population. We made the initial selections from this population based on characteristics identified by farmers, and at later stages farmers selected for themselves in populations grown by us. Three of the most promising white-grain varieties produced from the population were then assessed in formal and participatory trials.

Outstanding new variety

GDRM-187 was one of these three promising varieties. It was bred as an extra-early maturity maize variety. When farmers tested it in PVS trials, they liked the qualities of GDRM-187. It was very popular and high yielding in their fields over two seasons (Figure 2).

This variety matures earlier than the earliest local varieties by about seven days. It produces fewer barren plants and larger cobs, which, unlike local varieties, are filled to the tip (Figure 3). Farmers also noticed that the husk completely and tightly enclosed the cobs, thus reducing insect attack.

Farmers greatly appreciated the grain quality of the variety. By using our PVS programme to identify suitable parents, by selecting for characteristics valued by the farmers and by testing under the farmers' own conditions, a new and improved variety acceptable to farmers was rapidly produced.

Figure 2. **A farmer inspects his crop of GDRM-187. This new variety is popular with farmers because it is extra-early and produces a high yield.**

Figure 3. **The maize variety GDRM-187 (right) has much larger, more uniform cobs than the local variety.**

PVS follows PPB

PVS follows seamlessly from PPB. As soon as potential varieties have been produced by PPB, farmers test them using PVS. This is an important advantage as the results of PPB reach farmers more quickly than the results of conventional breeding, where varieties are typically tested with farmers only after a long delay for on-station testing and multiplication (Table 1). Delay in obtaining benefits reduces the rate of return on the investment in plant breeding. The economic value of this reduction in time can be very large.

Table 1. **A comparison of the breeding of maize cultivar GDRM-187 by participatory methods and the conventional breeding of maize cultivar GM-4.**

	GDRM-187 (PPB)	GM-4 (Conventional)
Years from cross to year of first testing	4 1993-1997	6 1989-1995
Years from cross to farmers	4 1993-1997	12 1989-2001
Days to 50% silking	45	50
Yield gain over check (%)	37 (over GM-1)	21 (over GM-1)

There is often a trade-off between yield and early maturity. An early variety escapes common end-of-season droughts, and produces a harvest at the hungriest time of the year, before other crops mature. It also reaches the market first, so its grain fetches a higher price.

The DFID Plant Sciences Research Programme has collaborated with GVT-West and TC consultants in the work reported here and in the preparation of this document.

Possible Outcomes/Benefits of PPB

- *Production gains*: yield increases; increases in stability of yield; faster uptake; wider diffusion; and higher market value of products.
- *Biodiversity enhancement*: communities have wider access to germplasm; wider access to related knowledge; and increased inter- and intra-varietal diversity.
- *Cost-efficiencies and effectiveness*: fewer research dead-ends; more opportunities for cost-sharing in research; and less expensive means of diffusing varieties.
- *Effective meeting of user needs*: higher degree of farmer satisfaction; broader range of users reached, including marginal farmers; and promotion of group learning through farm walks.

Building on the success

The Western India Rainfed Farming Project now has probably the largest - certainly the most diverse - PPB programme of any development project. Collaborative arrangements for PPB programmes are in place with three universities* in Madhya Pradesh, Rajasthan and Gujarat. These programmes include six crops: maize, rice, horsegram, black gram, niger and sunn hemp. A big advantage of this multi-crop approach is that large gains can be expected from breeding neglected crops, such as horsegram. They can also be bred to fit better into local farming systems - current horsegram varieties mature too late to successfully intercrop with maize. In time, short-duration maize and horsegram varieties from the PPB will be grown together by farmers.

These collaborative PPB programmes follow the principles described in this paper, and products from PPB in rice and maize are already in advanced trials. Considering the impact that just one new variety can have on improving farmers' livelihoods, the potential impact of this collaborative programme is immense.

* Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Madya Pradesh; Maharana Pratap University of Agriculture and Technology Udaipur, (MPUATU), Rajasthan; and Gujarat Agricultural University (GAU).

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Madhukar Tower, Ramkrishna Colony, Sardar Patel Marg, Jhabua-457661 (M.P.) **Tel. : 07392-44289, 43555 Fax : 44324**
E-mail : jbagvt@bom6.sancharnet.in

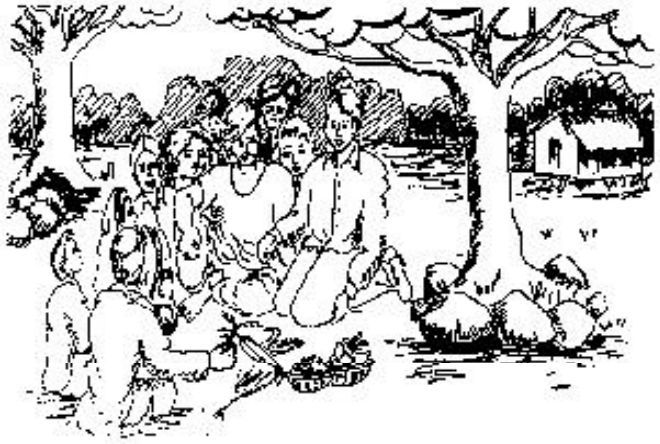
STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 44 Gulshan Bhawan, TIT Road, Ratlam-457001 (MP)
Tel. : 07412 - 20500, 33366, Fax : 33384 E-mail : gvtratlam@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 143, Taldar Building, Subhash Nagar, College Road, Banswara (Raj.) 327001, **Tel. : 02962-46888, 47888 Fax : 46889 Resi. : 48999**
E-mail : gvt_bsw@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Kanchan Kunj, Anand Bhawan Compound Chakaliya Road, Dahod-389151 (Gujarat), **Tel. : 02673-46984, 21311 Fax : 46392 Resi. : 46155**
E-mail : gvtdahod@ad1.sancharnet.in

SUNRISE PRINTERS, UDAIPUR Tel. : 0294-524780

WIRFP Participatory Plant Breeding: Concepts and Examples



Gramin Vikas Trust is implementing the Western India Rainfed Farming Project, funded by the Department for International Development, United Kingdom; Government of India; State Governments and Krishak Bharati Cooperative Limited (KRIBHCO). The project is working for sustainable livelihood enhancement of poor women and men in highly risk-prone, tribal-dominated areas covering seven districts - namely Jhabua, Dhar and Ratlam (Madhya Pradesh) Banswara and Dungarpur (Rajasthan), Dahod and Panchmahals (Gujarat). This paper presents the results of collaborative research in participatory plant breeding with Gujarat, Rajasthan and Madhya Pradesh agricultural universities.

Introduction

The centralised plant breeding techniques of the green revolution have yielded good results in the more favourable agricultural environments. Most low-resource farmers in the marginal areas of the project, however, have not benefited from these varieties (Figure 1). As an alternative to centralised breeding, farmer participatory approaches - participatory plant breeding (PPB) - are being adopted in the Western India Rainfed Farming Project.

PPB is an extension of Participatory Varietal Selection (PVS) (see *WIRFP Farmer-managed Participatory Research for Varietal Selection*, May 2002). In PPB, farmers are actively involved in the breeding process, from setting goals to selecting variable, early-generation material. In PVS, farmers are given a wide range of new cultivars to test for themselves in their own fields. In our PPB programmes we have exploited the results of PVS by using identified cultivars as parents of crosses.

Figure 1. **Resource-poor farmers often have to grow crops in low-quality soils in drought-prone environments. Conventional plant beeding has generally failed to produce varieties for these harsh conditions.**

REGISTERED OFFICE : Chief Executive Officer, Gramin Vikas Trust, H.No. 79, Sec. 15A, Noida-201301, Distt. Gautambudh Nagar (U.P.)
Tel. : 0118 - 4513720, 4513721, 4513729, 4513723, Fax : 4513726 E-mail : honoida@gvtindia.org

PROJECT OFFICE : Project Manager, Gramin Vikas Trust, 1, Chitragupta Society, E-7, Arera Colony, Bhopal - 462013 (M.P.)
Tel. : 0755 (O) 420932, Fax : 0755 - 420292 E-mail : gvtbhopal@sify.com Website : www.gvtindia.net

May 2002

Key assumptions for PPB

- Farmers are interested in participating in plant breeding
- Farmers and scientists can successfully collaborate.
- It will not fail because:
  - the parents of crosses include locally adapted material;
  - selection is in the local environment;
  - varieties are selected by farmers for the traits farmers consider important.

Types of PPB

PPB can be **consultative** and **collaborative**. The approach used will depend on the crop and the availability of resources.

Consultative

Farmers are consulted at every stage - for example, in setting the breeding objectives, choosing the appropriate parent, and by making joint selections with breeders from material grown by breeders. Hence, until there is a finished product from the breeding programme for farmers to test in PVS trials, farmers are not involved in growing material in their fields.

Collaborative

Farmers grow the variable PPB material in their own fields and select the best plants from it. Scientists can then obtain seed from farmers to test their selections in research station and participatory trials.

What crosses to make?

PVS can be efficiently followed by PPB since farmer-preferred cultivars are the ideal parents for PPB programmes. Examples are:

- PVS cultivar x high-yielding variety.
- Local landrace x PVS cultivar.
- Local landrace x high-yielding variety.

Steps for participatory plant breeding

1. Set the breeding objectives
   - Crop-focused PRAs
   - Analyse results of participatory varietal selection.

2. Identify the parent material
   - From local landraces
   - From varieties tested by PVS
   - From high-yielding varieties with complementary characteristics.

3. Decide on the model (consultative/collaborative)
   - On the basis of available resources
   - On the basis of the crop (collaborative participation is simpler in an inbreeding crop).

4. Enter the best participatory plant breeding lines in PVS trials and facilitate their entry in formal on-station trials.

5. Prepare release proposal, if success is achieved.

When to use PPB?

- When no existing cultivars are identified that are suitable for testing in a PVS programme.
- When PVS has been tried but has failed to identify any varieties that farmers prefer.

Advantages of participatory over conventional breeding methods

- At least one parent in any cross is well adapted to the local environment.
- Genotype x environment interactions are used positively because breeding is done in the target environment.
- The impact of genotype x year interaction is probably reduced because local parental materials have adapted to local year-to-year variations.
- Only a few crosses are made, so large F_2 and F_3 populations can be grown to increase the likelihood of selecting desirable segregants.

A case study - PPB in maize

Maize is the most important rainy season cereal crop in the marginal, upland areas of the project. We gave maize farmers in Gujarat, Rajasthan and Madhya Pradesh new varieties to try in a PVS programme. These included white- and yellow-grain types.

The farmers did not markedly prefer any of our varieties to their local ones. However, some of the varieties had specific traits that the farmers wanted, so in a PPB programme we crossed six of them to produce a composite population. We made the initial selections from this population based on characteristics identified by farmers, and at later stages farmers selected for themselves in populations grown by us. Three of the most promising white-grain varieties produced from the population were then assessed in formal and participatory trials.

Outstanding new variety

GDRM-187 was one of these three promising varieties. It was bred as an extra-early maturity maize variety. When farmers tested it in PVS trials, they liked the qualities of GDRM-187. It was very popular and high yielding in their fields over two seasons (Figure 2).

This variety matures earlier than the earliest local varieties by about seven days. It produces fewer barren plants and larger cobs, which, unlike local varieties, are filled to the tip (Figure 3). Farmers also noticed that the husk completely and tightly enclosed the cobs, thus reducing insect attack.

Farmers greatly appreciated the grain quality of the variety. By using our PVS programme to identify suitable parents, by selecting for characteristics valued by the farmers and by testing under the farmers' own conditions, a new and improved variety acceptable to farmers was rapidly produced.

Figure 2. **A farmer inspects his crop of GDRM-187. This new variety is popular with farmers because it is extra-early and produces a high yield.**

Figure 3. **The maize variety GDRM-187 (right) has much larger, more uniform cobs than the local variety.**

PVS follows PPB

PVS follows seamlessly from PPB. As soon as potential varieties have been produced by PPB, farmers test them using PVS. This is an important advantage as the results of PPB reach farmers more quickly than the results of conventional breeding, where varieties are typically tested with farmers only after a long delay for on-station testing and multiplication (Table 1). Delay in obtaining benefits reduces the rate of return on the investment in plant breeding. The economic value of this reduction in time can be very large.

Table 1. **A comparison of the breeding of maize cultivar GDRM-187 by participatory methods and the conventional breeding of maize cultivar GM-4.**

	GDRM-187 (PPB)	GM-4 (Conventional)
Years from cross to year of first testing	4 1993-1997	6 1989-1995
Years from cross to farmers	4 1993-1997	12 1989-2001
Days to 50% silking	45	50
Yield gain over check (%)	37 (over GM-1)	21 (over GM-1)

There is often a trade-off between yield and early maturity. An early variety escapes common end-of-season droughts, and produces a harvest at the hungriest time of the year, before other crops mature. It also reaches the market first, so its grain fetches a higher price.

The DFID Plant Sciences Research Programme has collaborated with GVT-West and TC consultants in the work reported here and in the preparation of this document.

Possible Outcomes/Benefits of PPB

- *Production gains*: yield increases; increases in stability of yield; faster uptake; wider diffusion; and higher market value of products.
- *Biodiversity enhancement*: communities have wider access to germplasm; wider access to related knowledge; and increased inter- and intra-varietal diversity.
- *Cost-efficiencies and effectiveness*: fewer research dead-ends; more opportunities for cost-sharing in research; and less expensive means of diffusing varieties.
- *Effective meeting of user needs*: higher degree of farmer satisfaction; broader range of users reached, including marginal farmers; and promotion of group learning through farm walks.

Building on the success

The Western India Rainfed Farming Project now has probably the largest - certainly the most diverse - PPB programme of any development project. Collaborative arrangements for PPB programmes are in place with three universities* in Madhya Pradesh, Rajasthan and Gujarat. These programmes include six crops: maize, rice, horsegram, black gram, niger and sunn hemp. A big advantage of this multi-crop approach is that large gains can be expected from breeding neglected crops, such as horsegram. They can also be bred to fit better into local farming systems - current horsegram varieties mature too late to successfully intercrop with maize. In time, short-duration maize and horsegram varieties from the PPB will be grown together by farmers.

These collaborative PPB programmes follow the principles described in this paper, and products from PPB in rice and maize are already in advanced trials. Considering the impact that just one new variety can have on improving farmers' livelihoods, the potential impact of this collaborative programme is immense.

* Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Madya Pradesh; Maharana Pratap University of Agriculture and Technology Udaipur, (MPUATU), Rajasthan; and Gujarat Agricultural University (GAU).

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Madhukar Tower, Ramkrishna Colony, Sardar Patel Marg, Jhabua-457661 (M.P.) **Tel. : 07392-44289, 43555 Fax : 44324**
E-mail : jbagvt@bom6.sancharnet.in

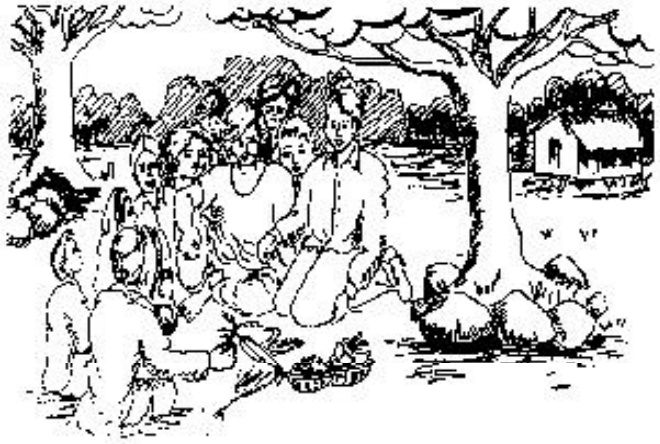
STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 44 Gulshan Bhawan, TIT Road, Ratlam-457001 (MP)
Tel. : 07412 - 20500, 33366, Fax : 33384 E-mail : gvtratlam@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 143, Taldar Building, Subhash Nagar, College Road, Banswara (Raj.) 327001, **Tel. : 02962-46888, 47888 Fax : 46889 Resi. : 48999**
E-mail : gvt_bsw@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Kanchan Kunj, Anand Bhawan Compound Chakaliya Road, Dahod-389151 (Gujarat), **Tel. : 02673-46984, 21311 Fax : 46392 Resi. : 46155**
E-mail : gvtdahod@ad1.sancharnet.in

SUNRISE PRINTERS, UDAIPUR Tel. : 0294-524780

WIRFP Participatory Plant Breeding: Concepts and Examples



Gramin Vikas Trust is implementing the Western India Rainfed Farming Project, funded by the Department for International Development, United Kingdom; Government of India; State Governments and Krishak Bharati Cooperative Limited (KRIBHCO). The project is working for sustainable livelihood enhancement of poor women and men in highly risk-prone, tribal-dominated areas covering seven districts - namely Jhabua, Dhar and Ratlam (Madhya Pradesh) Banswara and Dungarpur (Rajasthan), Dahod and Panchmahals (Gujarat). This paper presents the results of collaborative research in participatory plant breeding with Gujarat, Rajasthan and Madhya Pradesh agricultural universities.

Introduction

The centralised plant breeding techniques of the green revolution have yielded good results in the more favourable agricultural environments. Most low-resource farmers in the marginal areas of the project, however, have not benefited from these varieties (Figure 1). As an alternative to centralised breeding, farmer participatory approaches - participatory plant breeding (PPB) - are being adopted in the Western India Rainfed Farming Project.

PPB is an extension of Participatory Varietal Selection (PVS) (see *WIRFP Farmer-managed Participatory Research for Varietal Selection*, May 2002). In PPB, farmers are actively involved in the breeding process, from setting goals to selecting variable, early-generation material. In PVS, farmers are given a wide range of new cultivars to test for themselves in their own fields. In our PPB programmes we have exploited the results of PVS by using identified cultivars as parents of crosses.

Figure 1. **Resource-poor farmers often have to grow crops in low-quality soils in drought-prone environments. Conventional plant beeding has generally failed to produce varieties for these harsh conditions.**

REGISTERED OFFICE : Chief Executive Officer, Gramin Vikas Trust, H.No. 79, Sec. 15A, Noida-201301, Distt. Gautambudh Nagar (U.P.)
Tel. : 0118 - 4513720, 4513721, 4513729, 4513723, Fax : 4513726 E-mail : honoida@gvtindia.org

PROJECT OFFICE : Project Manager, Gramin Vikas Trust, 1, Chitragupta Society, E-7, Arera Colony, Bhopal - 462013 (M.P.)
Tel. : 0755 (O) 420932, Fax : 0755 - 420292 E-mail : gvtbhopal@sify.com Website : www.gvtindia.net

May 2002

Key assumptions for PPB

- Farmers are interested in participating in plant breeding
- Farmers and scientists can successfully collaborate.
- It will not fail because:
  - the parents of crosses include locally adapted material;
  - selection is in the local environment;
  - varieties are selected by farmers for the traits farmers consider important.

Types of PPB

PPB can be **consultative** and **collaborative**. The approach used will depend on the crop and the availability of resources.

Consultative

Farmers are consulted at every stage - for example, in setting the breeding objectives, choosing the appropriate parent, and by making joint selections with breeders from material grown by breeders. Hence, until there is a finished product from the breeding programme for farmers to test in PVS trials, farmers are not involved in growing material in their fields.

Collaborative

Farmers grow the variable PPB material in their own fields and select the best plants from it. Scientists can then obtain seed from farmers to test their selections in research station and participatory trials.

What crosses to make?

PVS can be efficiently followed by PPB since farmer-preferred cultivars are the ideal parents for PPB programmes. Examples are:

- PVS cultivar x high-yielding variety.
- Local landrace x PVS cultivar.
- Local landrace x high-yielding variety.

Steps for participatory plant breeding

1. Set the breeding objectives
   - Crop-focused PRAs
   - Analyse results of participatory varietal selection.

2. Identify the parent material
   - From local landraces
   - From varieties tested by PVS
   - From high-yielding varieties with complementary characteristics.

3. Decide on the model (consultative/collaborative)
   - On the basis of available resources
   - On the basis of the crop (collaborative participation is simpler in an inbreeding crop).

4. Enter the best participatory plant breeding lines in PVS trials and facilitate their entry in formal on-station trials.

5. Prepare release proposal, if success is achieved.

When to use PPB?

- When no existing cultivars are identified that are suitable for testing in a PVS programme.
- When PVS has been tried but has failed to identify any varieties that farmers prefer.

Advantages of participatory over conventional breeding methods

- At least one parent in any cross is well adapted to the local environment.
- Genotype x environment interactions are used positively because breeding is done in the target environment.
- The impact of genotype x year interaction is probably reduced because local parental materials have adapted to local year-to-year variations.
- Only a few crosses are made, so large F_2 and F_3 populations can be grown to increase the likelihood of selecting desirable segregants.

A case study - PPB in maize

Maize is the most important rainy season cereal crop in the marginal, upland areas of the project. We gave maize farmers in Gujarat, Rajasthan and Madhya Pradesh new varieties to try in a PVS programme. These included white- and yellow-grain types.

The farmers did not markedly prefer any of our varieties to their local ones. However, some of the varieties had specific traits that the farmers wanted, so in a PPB programme we crossed six of them to produce a composite population. We made the initial selections from this population based on characteristics identified by farmers, and at later stages farmers selected for themselves in populations grown by us. Three of the most promising white-grain varieties produced from the population were then assessed in formal and participatory trials.

Outstanding new variety

GDRM-187 was one of these three promising varieties. It was bred as an extra-early maturity maize variety. When farmers tested it in PVS trials, they liked the qualities of GDRM-187. It was very popular and high yielding in their fields over two seasons (Figure 2).

This variety matures earlier than the earliest local varieties by about seven days. It produces fewer barren plants and larger cobs, which, unlike local varieties, are filled to the tip (Figure 3). Farmers also noticed that the husk completely and tightly enclosed the cobs, thus reducing insect attack.

Farmers greatly appreciated the grain quality of the variety. By using our PVS programme to identify suitable parents, by selecting for characteristics valued by the farmers and by testing under the farmers' own conditions, a new and improved variety acceptable to farmers was rapidly produced.

Figure 2. **A farmer inspects his crop of GDRM-187. This new variety is popular with farmers because it is extra-early and produces a high yield.**

Figure 3. **The maize variety GDRM-187 (right) has much larger, more uniform cobs than the local variety.**

PVS follows PPB

PVS follows seamlessly from PPB. As soon as potential varieties have been produced by PPB, farmers test them using PVS. This is an important advantage as the results of PPB reach farmers more quickly than the results of conventional breeding, where varieties are typically tested with farmers only after a long delay for on-station testing and multiplication (Table 1). Delay in obtaining benefits reduces the rate of return on the investment in plant breeding. The economic value of this reduction in time can be very large.

Table 1. **A comparison of the breeding of maize cultivar GDRM-187 by participatory methods and the conventional breeding of maize cultivar GM-4.**

	GDRM-187 (PPB)	GM-4 (Conventional)
Years from cross to year of first testing	4 1993-1997	6 1989-1995
Years from cross to farmers	4 1993-1997	12 1989-2001
Days to 50% silking	45	50
Yield gain over check (%)	37 (over GM-1)	21 (over GM-1)

There is often a trade-off between yield and early maturity. An early variety escapes common end-of-season droughts, and produces a harvest at the hungriest time of the year, before other crops mature. It also reaches the market first, so its grain fetches a higher price.

The DFID Plant Sciences Research Programme has collaborated with GVT-West and TC consultants in the work reported here and in the preparation of this document.

Possible Outcomes/Benefits of PPB

- *Production gains*: yield increases; increases in stability of yield; faster uptake; wider diffusion; and higher market value of products.
- *Biodiversity enhancement*: communities have wider access to germplasm; wider access to related knowledge; and increased inter- and intra-varietal diversity.
- *Cost-efficiencies and effectiveness*: fewer research dead-ends; more opportunities for cost-sharing in research; and less expensive means of diffusing varieties.
- *Effective meeting of user needs*: higher degree of farmer satisfaction; broader range of users reached, including marginal farmers; and promotion of group learning through farm walks.

Building on the success

The Western India Rainfed Farming Project now has probably the largest - certainly the most diverse - PPB programme of any development project. Collaborative arrangements for PPB programmes are in place with three universities* in Madhya Pradesh, Rajasthan and Gujarat. These programmes include six crops: maize, rice, horsegram, black gram, niger and sunn hemp. A big advantage of this multi-crop approach is that large gains can be expected from breeding neglected crops, such as horsegram. They can also be bred to fit better into local farming systems - current horsegram varieties mature too late to successfully intercrop with maize. In time, short-duration maize and horsegram varieties from the PPB will be grown together by farmers.

These collaborative PPB programmes follow the principles described in this paper, and products from PPB in rice and maize are already in advanced trials. Considering the impact that just one new variety can have on improving farmers' livelihoods, the potential impact of this collaborative programme is immense.

* Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Madya Pradesh; Maharana Pratap University of Agriculture and Technology Udaipur, (MPUATU), Rajasthan; and Gujarat Agricultural University (GAU).

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Madhukar Tower, Ramkrishna Colony, Sardar Patel Marg, Jhabua-457661 (M.P.) **Tel. : 07392-44289, 43555 Fax : 44324**
E-mail : jbagvt@bom6.sancharnet.in

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 44 Gulshan Bhawan, TIT Road, Ratlam-457001 (MP)
Tel. : 07412 - 20500, 33366, Fax : 33384 E-mail : gvtratlam@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, 143, Taldar Building, Subhash Nagar, College Road, Banswara (Raj.) 327001, **Tel. : 02962-46888, 47888 Fax : 46889 Resi. : 48999**
E-mail : gvt_bsw@rediffmail.com

STATE OFFICE : Western India Rainfed Farming Project, GRAMIN VIKAS TRUST, Kanchan Kunj, Anand Bhawan Compound Chakaliya Road, Dahod-389151 (Gujarat), **Tel. : 02673-46984, 21311 Fax : 46392 Resi. : 46155**
E-mail : gvtdahod@ad1.sancharnet.in

SUNRISE PRINTERS, UDAIPUR Tel. : 0294-524780