

Benefits and Costs of Participatory Barley Breeding in Syria

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Abstract

Scientists are increasingly applying participatory approaches to their research to better understand clients needs and to design agricultural technologies that fit the complexity of poor people's livelihoods. This paper assesses benefits and costs of ICARDA's participatory barley breeding approach as compared to the conventional (centralized) breeding approach; both at the farmer level, and as returns to research.

The methods used include economic methods of measuring benefits from adoption, and from "process impacts" which occur because of the participation itself rather than because of the technologies developed. We calculated the opportunity costs of farmers time in research and analyzed the change in research costs due to breeding approach.

Our results show that there are potentially significant increases to Syrian agriculture from participatory barley breeding. Findings indicate that the infrastructure and personnel constitute the largest share of breeding budget. The given breeding approach (e.g. conventional, decentralized, participatory) or breeding method used (bulk, pedigree) affects the operational costs which represent a relatively small share of the total breeding budget. Moving from conventional breeding to participatory breeding affects the allocation of the total operational costs, and the biggest change is due to the decentralization of breeding (moving from station to on-farm). Adding participatory trials increases the operational costs slightly, but relative change in total cost structure is insignificant. Opportunity cost of farmers time varies according to their participation intensity, and represents a sizeable amount. Participation in research increases farmers skills and implies some economic benefits from learning.

Keywords: participatory, benefits, costs, barley, Syria

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Introduction

There is growing perception in the research and development community that research without farmer involvement in technology development and evaluation has limited value to the low-income people in developing countries. This has resulted in a major change in research approach, and farmer participatory research has significantly gained importance in the international agricultural research centers, particularly in plant breeding. We can no longer claim that participatory research is a marginalized activity, as there is a sizeable amount of both budget resources and human capacity invested in it. According to a survey in 2000, the Consultative Group in International Agricultural Research (CGIAR) reported 144 projects which involve participatory research with a total budget of US\$65 million.

The increased use of participatory methods is induced by the perceived benefits from increased relevance of research results because of participatory research. Although participatory plant breeding has become more systematic and recognized approach to breeding, there are still very few studies available about benefits and costs of participatory breeding compared to more conventional approaches. A literature review failed to reveal any studies on the benefits and costs of participatory breeding and there are very few cost-benefit studies available on plant breeding programs in general. The results of this study should be useful in pinpointing the key differences in benefits and costs of different breeding approaches, and allow some judgment to be made as to whether one approach to plant breeding is economically more desirable than other.

Background

ICARDA has used decentralized-participatory barley breeding in Syria since 1996. The barley breeding program has evolved from centralized breeding to decentralized and then to decentralized-participatory breeding. The decentralized-participatory breeding begun when the initial 208 barley lines were planted on farmers' fields in nine villages throughout Syria in 1997. The participatory barley breeding at ICARDA can be described currently operating at a "sustainable rate." What we mean is, that it is not in its transition stage, but that the participatory research been institutionalized in the breeding program.

One widespread and rather untested critique about the participatory breeding has been that farmers are not able to examine, express judgment, and translate that judgment in a quantitative score on a large number of breeding lines. ICARDA technical findings have demonstrated that farmers can indeed handle the evaluation of large number of breeding lines, and are efficient in doing so (Ceccarelli, 2000).

According to ICARDA's current breeding approach, each year a large sample of barley lines are planted on a farmer's field in several locations, and they are called Farmer initial trials (FIT). These lines are a random sample of barley lines representing initial stages of breeding process, that is lines that are normally planted on the research station. The lines represent different types of germplasm, 2 and 6-row, modern and landraces, uniform lines and segregating populations, black and white seed color. The materials which are selected by farmers in the farmer initial trials are then planted in the second year on fields of several host farmers in each location. These are called farmer advance trials (FAT). Material selected from the farmer advance trials enter the Farmer elite trials on the third year (FET). Each year a new FIT trial is also initiated which sets off the advanced and elite trials in the subsequent years. Breeders' role

is to make the initial crosses and increases on station and provide the genetic material for the trials, and keep records about the agronomic characteristics of the lines. Farmer's role is to manage the trials, select, and record their selections. Breeders and farmers together discuss and decide what materials go to different trials.

Conceptual Model

It is assumed that the type of participatory research approach (functional or empowering) and the stages when it was applied influences the process of innovation and leads to some intermediary, process impacts. For example, project's research objectives are consistent with clients' needs because they are involved in project planning, and social and human capital formation impacts, such as participating clients are empowered to carry out some of their own experiments and seek and find solutions on their own. From this process, which is shaped by the participatory approach used and stage of research when applied, there will be some research outcomes or adoption (technology) impacts. The adoption impact will influence the welfare outcome of the project in terms of who benefits, or how benefits were distributed, and equity issues. It is hypothesized that participatory research will lead to greater impacts than non-participatory approaches.

Methodology

The objective of this impact study is to measure the benefits and costs of decentralized-participatory barley breeding approach as compared to conventional approach to barley breeding. This requires assessing the benefits at the program level and at the farmer level. Measuring the impact of a breeding approach requires comparing the impacts which have been achieved to a

counterfactual. Hence, we need to compare ICARDA's current participatory approach to other breeding approaches. The three breeding approaches which are used in this analysis are 1) conventional (=centralized); 2) decentralized; and 3) decentralized-participatory breeding. The main difference between the three approaches is in who does the selection and where the selection is done. In the centralized or conventional approach, the selection is done by the breeder in the research station. In the decentralized approach, the selection is done by the breeder in the farmers' fields, and in the decentralized participatory approach, the selection is done by farmers in their own fields.

We used a standard economic surplus model (Alston et al. 1995) to calculate the discounted benefits induced by the new barley cultivars in Syrian agriculture to two different scenarios: to conventional, to decentralized participatory breeding. (what happened to the third approach?) We compared cost structures for operating a decentralized breeding program and a conventional (centralized) breeding program based on the actual costs of the current ICARDA program.

Costs of the breeding program are difficult to disaggregate. Our approach to analyzing the costs of participatory breeding as compared to other approaches was to first assess the cost structure of the current decentralized-barley breeding program. We used breeders' expert opinion about changes in breeding activities due to changes in breeding approach (which have cost associated with them) in order to construct operational cost budgets for the conventional and decentralized approaches.

The farmer-level impacts are assessed through a survey conducted in 2001 of 86 farmers who participated in ICARDA's barley evaluation research, and 106 non-participating farmers. The methods used included conventional economic methods of measuring benefits from

adoption of technology, but we also used non-conventional approaches to impact assessment and tried to capture a wider scope of impacts, including “process impacts” which occur as a result of the participation itself rather than as a result of the technologies developed via participatory research methods. The type of interaction between scientists and farmers directly affects the kinds of process impacts that occur, and indirectly affects the nature of resulting technology as well as types of beneficiaries. The process impacts assessed in this study include effectiveness of targeting the users and human capital changes. We also calculated the opportunity cost of farmers time in research.

Data

The sources of data for economic modeling and analysis were numerous. The secondary sources of data include Syrian national production and price statistics, ICARDA economic studies, as well as breeding program annual reports. The primary sources of data included interviews with ICARDA breeders and household surveys of 193 barley farmers in 2001-2002. The current barley breeder has been with ICARDA for a long time and has significant institutional memory of the program. He has participated in the program transition from centralized breeding to decentralized participatory breeding and therefore provides an excellent expert opinion particularly on the changes in breeding operations which imply changes in breeding costs. A 5-year seed tracer study done by ICARDA since 1994 which followed released varieties over time was an important basis for modeling the adoption profiles for different breeding approaches, that is, the speed of adoption and the adoption ceiling, or the maximum amount of area planted in the new cultivar (Aw-Hassan, 2002 forthcoming). The study tracked

the adopting pattern of the seed that was distributed to 52 farmers in 1994 in five provinces of Syria, and the seeds were traced yearly until 1999.

Model Assumptions

The model assumes an annual barley production of 874,060 MT, and it is based on the Syrian national production statistics in 1994-99 for zones 2 and 3. Base yield is 822 kg/ha and it is the weighted average of the zone 2 and 3, also from the Syrian national production statistics (zone 4 cultivation is discouraged by government, zones 2 and 3 represents about 75% of total barely area in the country.) A conservative breeder's yield increase estimate for the modern barley cultivars, both from what has been developed through conventional recently, and what is going through the "pipeline" now with the participatory breeding, is 10% yield advantage over local landrace yield. For price we used c.i.f. average for 1995-2000, which is 141 USD/MT, and we used a discount rate of 3% for the model. Annual benefits from new barley cultivars are projects for 23 years after research commences. We used 50% as the probability that the research will achieve the 10% yield gain. These are very conservative assumptions, which imply that the model tends to underestimate the benefits.

Research and Development Lag

An important driver of the size of the benefits from research in a given year is the research and development lag, that is the time it takes from the initiation of the research to adoption. One of the main expected outcomes from decentralized participatory breeding is that it will reduce this lag. Table 1 illustrates how research and development lag differs between conventional and participatory approaches. The first two years of the research structure are the

same, the crosses are made and initial increases are made on-station. ICARDA's participatory barley breeding takes the lines to farmer selection in year 3, whereas on-farm testing in conventional breeding takes place 3 years later, in year 6. This means that participatory research has potentially a 3-year reduction research lag. The conventional breeding research lag is 8 years at the minimum. After 8 years, there is a 2 more years of large scale testing before variety can be released. If single plant selections are done then the pedigree method adds at least 3 more years because materials are not bulked until year 5.

Adoption profiles

Table 2 shows the adoption profiles for the conventional approach and three different possible participatory approaches (PPB 1-3). The research lag was set at 12 years for conventional as it takes 12 years from the time research commences for a cultivar to be developed. The research lag participatory research was set at 8 years, as explained in table 1. The speed of the varietal adoption depends on 1) profitability of the technology, 2) farmers awareness/access to information about the technology, and 3) availability of the seed. The seed tracer (2002) study shows that the average speed of adoption of new barley varieties in Syria is 3%. In the PPB1 and PPB2 scenarios we make a very conservative assumption and assumed that the speed of adoption of participatory-bred lines is the same as the speed of adoption of conventional lines (3%). Because it is known (Witcombe, 1999) that the speed of adoption is in some cases faster with the technologies developed through participatory means, we evaluated a scenario (PPB3) where the adoption speed is 10%.

Adoption ceiling is the area of the total barley area that will be planted under new technology. From the seed tracer study we know that the adoption ceiling for modern barley

varieties is 25% and we used that as an adoption ceiling in the PPB1 scenario. Farmers in the household survey reported that they would plant up to 60% of their total area in varieties from the participatory trials, hence we are evaluating higher adoption ceiling in PPB2 and PPB3 scenarios. Conventional barley varieties have lower adoption ceiling potential (25%) because of their limited capacity to adapt to the different conditions of the marginal environments which are characteristic of area where barley is grown. Based on these adoption patterns, we also calculated the time it takes to reach the ceiling.

Results

The results show that the discounted research induced benefits to Syrian agriculture from conventional barley breeding are 21.9 m \$US (table 3). The model results also show that the benefits in reduction in research lag and 10% yield increase due to participatory research increases total benefits by 90% (42.7 m \$US). Higher adoption ceiling for the participatory breeding as compared to conventional breeding increases the benefits further 50% (54.6 m \$US), and if we also allow for faster adoption speed, the benefits are increased by 260% (113.9 m \$US) compared to conventional breeding. These are ex ante estimations of potential benefit of PPB, and realizing these benefits partially depends on the functioning extension and seed systems – as without them autonomous diffusion may be slow.

Costs

ICARDA's current barley breeding budget of 1.5 million \$US devotes 47% to personnel costs, 30% to overhead, and 23% to operational costs. This represents a realistic situation where the operating budget represents less than a quarter (this is a wide range do we rather say close to

a quarter) of the total budget. The operational cost is nearly equally divided between on-station in Syria and off-station work in other countries, and only a small portion is allocated to off-station work in Syria, which include farmer participatory trials.

After disaggregating the current operational budget per breeding activity and their respective resource allocations, we used breeders' expert opinion to try to analyze how participatory approach differs from conventional and decentralized breeding in terms of operating costs. Because the barley breeder has been at ICARDA for many years, he has been involved in conventional, decentralized and participatory breeding there, and hence has the ability to make a realistic estimation of cost changes.

Table 4 shows the relative changes per breeding activity due to breeding approach used. For example, in the current participatory barley-breeding program, there is a 10% increase in the amount increases made on-station as compared to decentralized breeding and 25% increase as compared to conventional breeding. The most obvious cost changes due to participatory research are decrease in on-station yield and biotic testing, and the cost increases are due to participatory trials.

The relative changes in costs were then calculated to changes in budget allocations due to breeding approach, and the shift from conventional to participatory research increased the operating costs by 56% (122,154 \$US). However, it would be erroneous simply to conclude that PPB is more costly than conventional breeding. In reality, share of the overhead and personnel cost remains fixed, and operations are adjusted accordingly depending on the availability of funds. Also, most breeding programs today are already decentralized, and what our results show is that the changes in costs from decentralized to participatory decentralized breeding is very

small. Further calculation shows that the move from conventional to participatory breeding only increases the total breeding budget by 2%.

Farmer benefits

We conducted a farmer survey of 195 barley farmers in Syria. We interviewed three types of farmers who participated in ICARDA's participatory barley work, and they can be classified by their participation "intensity": 1) Original host farmers, whom we call "Pioneers", 2) Farmers who host advanced trials, whom we call "hosts", and 3) Farmers who do not host trials but are involved in field evaluations only, and whom we call the "evaluators." We interviewed two types of non-participating farmers 1) Farmers who are not involved in PPB work but have been involved with ICARDA on-farm trials in the past, and the 2) Farmers who never have had any involvement with ICARDA.

We tested several hypothesis about the economic benefits to farmers, two of which are presented here are: 1) It is hypothesized that PPB increases the probability of adoption. It is claimed that the proportion of the targeted beneficiary group that could potentially be reached by the project increases because the research is more relevant to the needs and priorities of targeted farmers, and because farmers have been involved in the process; 2) it is hypothesized that due to the interaction with researchers and by becoming involved in research, farmers skills are increased.

Differences between participating and non-participating farmers were tested on several variables. Our results show that there are no significant differences between the participating and non-participating farmers in terms of family size, crops grown or relative allocation of crops, sources of income, animal ownership, uses of barley and portion sold or home consumed, or their

experience in farming or participation in other agricultural projects nor in their varietal preferences regarding what they are currently cultivating. These similarities combined with the test of some other variables indicate that participating farmers are “representative” farmers.

However, there were some significant difference between the participants and non-participants in term of their farm size, use of modern varieties and their estimation of number of unfavorable agricultural years in the past 10 years indicating batter ability to respond to unfavorable agricultural conditions, perhaps due to higher use of modern varieties. The larger farm size of the participating farmers is likely explained by the fact that larger farmer size allows farmers to participate, they have more land to experiment and are therefore more prone to self-select to participate. The two other significant differences, higher use of modern barley varieties and better ability to respond to unfavorable conditions may be interpreted as results of participation itself, rather than a true difference between the participants and non-participants, as the higher use of modern varieties is probably learned in the course of being participant, due to increased awareness and available information.

Table 5 presents the results of the variables indicating adoption potential of the new varieties the participating farmers had seen in the ICARDA PPB trials. The participating farmers expect a 25% yield increase of the new barley over their local variety, this is much higher that the breeders’ moderate estimate of 10% yield increase. The participating farmers estimated that they will plant 69% of their total barley area on the new barley lines, after their own initial 2 year experimenting period. (this experimentation is 2 years after ICARDA trials.) The 69% represents the adoption ceiling for the varieties developed through the participatory breeding program. The participating farmers were also willing to pay a 24% premium on the new barley seed over the local seed.

Ninety-one percent of the participating and 63% of the non-participating farmers said that they had learned something new about barley production in the past 5 years ($X^2 = 19.754$, sig.=0.001). There were no significant difference between participants and non-participants in terms of their prior attendance in other agricultural projects, this difference in stated learning experience can therefore be contributed to the ICARDA's participatory project.

There was no significant differences between the participants and non-participants in ranking of ideal characteristics in currently cultivated barley varieties, but there was a difference in ideal characteristics they would like to see in a new barley variety, indicating that participants had increased ability to articulate their desired varietal improvements.

Farmer costs

We calculated the opportunity cost of farmers time in participating in the barley research (Table 6). If we value farmers time at the official rural minimum wage rate, the opportunity cost of their time is 2 weeks salary at the higher intensity of participation (masters). Most time consuming activity was planting, harvest and threshing, and meetings and evaluation in the spring.

Conclusions

Our results show that there are potentially significant increases to Syrian agriculture from participatory barley breeding. Findings indicate that the infrastructure and personnel constitute the largest share of breeding budget. The given breeding approach (e.g. conventional, decentralized, participatory) or breeding method used (bulk, pedigree) affects the operational costs which represent a relatively small share of the total breeding budget. Moving from

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Tables

Table 1: Research and Development lag

	CONVENTIONAL		DECENTRALIZED PARTICIPATORY
Yr1		Cross	
Yr1		Initial Increase	
Yr3	Breeder initial trial		Farmer initial trial
Yr4	Breeder preliminary trial		Farmer advanced trial
Yr5	Breeder advanced trial		Farmer elite trial
Yr6	On-farm trial / year1		Large scale trial / year 1
Yr7	On-farm trial / year2		Large scale trial / year 2
Yr8	On-farm trial / year3		
Yr9	Large scale trial / year 1		
Yr10	Large scale trial / year 2		

Table 2: Adoption profiles

	Conventional	PPB1	PPB2	PPB3
Research lag	12 years	8 years	8 years	8 years
Adoption speed	3%	3%	3%	10%
Adoption ceiling	25%	25%	60%	60%
Time to reach the ceiling	8 years	8years	19 years	6 years

Table 3: Economic surplus model results

	Conventional	PPB1	PPB2	PPB3
Total millions \$US	21.9	42.7	54.6	113.9

Table 4: Cost changes related to participatory research

	Decentralized	Conventional
On-station operations		
Crosses	0%	0%
Increases	+10%	+25%
Selection	-30%	-30%
Yield testing	-100%	-100%
Abiotic testing	-30%	-90%
Biotic testing	0%	0%
Molecular testing	+5%	+5%
International nurseries	-10%	-10%
Active seed storage	+25%	+25%
Off-station activities		
Centralized trials	0%	0%
De-centralized trials	+100%	+0%
On-farm trials	-50%	-80%
Participatory trials	0%	+100%

Table 5: Adoption potential

	Mean	St.Dev.
Expected yield advantage over local	26%	14.5
Expected % of total land planted in new variety	69%	33.3
Length of own experimentation needed before replacing the local	2 years	1.6
Willingness to pay for the new seed	8.3 SL/kg	1.2
Current farmer cost of local seed	6.7 SL/kg	0.3

N=87

Table 6: Opportunity cost of farmers time in participatory activities*

Farmer type	Average total time in participatory activities	Opportunity cost per farmer type
Pioneers	72.9 hrs	\$ 22.60
Hosts	42.1 hrs	\$ 13.01
Evaluators	8.6 hrs	\$ 2.70

*valued at minimum rural wage rate = \$49/month, N=87