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Advantages and Disadvantages of Participatory Plant Breeding (PPB) in Iran: A Study Based on Breeders' Perceptions

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Abstract

The purpose of this study was to investigate the advantages and disadvantages of Participatory Plant Breeding (PPB). Seventy-six breeders were randomly selected from among 95 breeders who were working at the Seed and Plant Improvement Institute, Karaj, Iran. Data were collected by a questionnaire as the main data collection instrument. The face and content validity of the questionnaire was approved by a panel of agricultural extension and plant breeding experts. The reliability of the questionnaire was calculated and it turned out to be high, ranging from 0.83-0.92. The descriptive findings of the study suggested that the breeders had generally positive perception toward using PPB. The correlation analysis results showed that there is a positive and significant ($p>0.01$) correlation among the levels of familiarity with PPB, advantages, and breeders' perception toward the use of PPB. In addition, there was a negative and significant ($p>0.01$) correlation between breeders' perception of the disadvantages faced by PPB and their perception of using participatory plant breeding. Finally, stepwise regression analysis indicated that the advantages and disadvantages of PPB explained about 58% of the variations in breeders' perception toward using PPB.

Keywords:
agricultural extension, participatory approach, participatory plant breeding, breeders' perceptions

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INTRODUCTION

One of the major concerns of agricultural extension systems is to encourage the farmers to participates extension programs and use new technologies in agriculture (Fami, 2006). So far, efforts have been made to develop agriculture through the use of variation technologies. The goal of all these attempts has been to increase quantity of production that was started along with the green revolution in 1950s and has been going on up to now. Yet, such efforts have led to a number of crises: soil erosion, pollution of water resources, overuse of chemical materials, as well as destruction of natural wildlife and insects are expressed as only small amount of concerns voiced by environmentalists, producers, and policy makers (Gang et al., 2010).

In addition, one of the current challenges in management of agricultural extension is farmer's participation in extension programs, dissemination of technology, and new innovation. Therefore, in order to achieve sustainability in agriculture, political efforts should be followed more seriously and also practical methods must be designed based on the local knowledge and skills which will result in improvement and co-operational solutions in sustainable agriculture (Fami, 2006). Effective political decision could bring different organizations together in order to investigate the reality and unpredictable situations. This will provide new guidelines in partnership agriculture (Rolling & Pretty, 1997). One of these guidelines that has focused on partnership with farmers is the PTD (Participatory Technology Development) model. This model is built upon devoting attention to partnership with farmers in extending new technologies. Such programs will increase farmers' self-confidence and creativity (David, 1999). Due to high needs of fertilizers and other chemicals in new variety developed by conventional breeding programs, many small farmers who are not able to afford fertilizers cannot adopt new varieties. These farmers normally work on small farms in hard working conditions and do not benefit from new varieties because of their high associated cost. These problems led to the development of programs called (PPB) in 1980 (Ceccarelli, 2008).

A PPB program started in Syria in 1996 by ICARDA and was successfully performed and extended to Tunisia, Morocco, Jordan, Egypt, Yemen, Eritrea, and Ethiopia, and finally, to Iran in 2006 (Bhargav & Meena, 2014). PPB is a complement to conventional breeding approaches. Participatory plant breeding is perceived by several scientists as a way to overcome the limitations of conventional breeding by offering farmers the possibility to decide which varieties suit better their needs and conditions without exposing their household to any risk during the selection progress (Bhargav & Meena, 2014). Moreover, PPB program is a dynamic process in which the roles of patterns and the extent and also the manner of their collaboration change over the time (Ceccarelli, 2012).

Despite the differences between crops producers and breeders, in all breeding programs, it is possible to identify three main stages:

- Generating genetic variability;
- Selection of the best genetic material within the genetic variability created in the first stage and;
- Testing of breeding lines.

One of the main goals of international agricultural research centers that work on participatory research is to develop a database of farmers' indigenous knowledge and its requirements and reasons. Accordingly, systematic records of farmers' knowledge and their use in breeding programs could be regarded as an important outcome of Participatory Plant Breeding (PPB) (Ceccarelli, 2009). As such, effective knowledge and technology transfer to the farming communities, using a combination of scientific and practical expertise, is of high importance (Mayer, 2013). According to researches, more than 75% of poor people in the world are livelihood farmers who live in developing countries. These farmers produce more than 90% of consumed seeds in developing countries (Ceccarelli et al., 2000). Therefore, in these countries, the implementation of PPB programs would increase the efficiency and effectiveness of plant breeding programs. As a result, the major part of breeding programs in PPB is adequately shifted from research stations to farmers' fields (Ceccarelli & Grando, 2008). Likewise, PPB encourages two kinds of participation:

Functional participation:

• Plant breeders can direct their research according to the needs of the specific groups of farmers (women, men, rich and poor). Hence, physical and economic resource bases of different people necessitate tailored research approaches.

• Farmers can assure plant breeders that they are assessing tradeoffs among traits correctly.

• On-farm research assures that varieties will produce well under "real life" conditions. On farm research can be managed by the researcher, farmer, or both.

• PPB ensures greater success of innovation adoption by the farmers.

Empowering participation:

• Increasing farmer knowledge and skills so that farmers can better participate in collaborative breeding efforts and be more successful in their personal efforts (Bhargav & Meena, 2014).

The main goal of involving farmers, then, is to improve client orientation, and highly client-oriented breeding (COB) describes this purpose, whereas PPB describes an activity (Mayer, 2013). Results of this project in Iran in 2007 showed that PPB is an effective strategy for farmers' empowerment to be able to solve their own problems and to decrease their production costs (Heidari et al., 2007). In a study by Maghirang et al. (2014), some farmers learned how to keep their production records, sales and selections, as well as the seeds that they produce, sell, and distribute among other farmers. A number of varieties were developed and released through PPB in Guangxi, south west of China during 2000 to 2011 (Yiching & Jingsing, 2011). Bhargav and Meena (2014) expressed more opportunities for cost sharing in research and less expensive means of diffusing varieties. Reaching user needs effectively and higher degree of farmers' satisfaction are some examples of the benefits of PPB.

Although PPB has many potential advantages, it also has several potential shortcomings such as high overall cost of breeding programs, high costs of participating farmers, and additional training needed for scientists which impose extra expenses as well (Morris & Bellon, 2004).

Aref (2010) reported the lack of proper planning for rural development as a deterrent factor in sustainable agriculture. Some other factors he underlined could be noted as: the lack of funding resources, the shortage of human resources development, lack of necessary funds to provide governmental supports for farmers, lack of local agricultural organization and farmers' limited, and insufficient knowledge. Lahmar (2010) mentioned the living – physical conditions, political, institutional and technical, cultural, and social ambiances as the most important barriers of advancing sustainable agriculture programs like PPB. In addition, Surangsari and Nuta (2005) mentioned the most important reasons for rejecting PPB methods by farmers as: lack of tangible positive results during the short term, lack of enough knowledge, and the shortage of farmers' encouragement toward participatory approaches. Taking all these into account, PPB was developed as an alternative and complementary breeding approach to conventional plant breeding. Conventional plant breeding is generally carried out by trained breeders in standard laboratory and controlled environment which is of course under favorable farming conditions. While PPB oppositely breeders, farmers and other consumers or end users such as rural farm associations or cooperatives involves in plant breeding activities. This approach enables plant breeders to better understand local farming conditions, farmers' traditional ways for managing plant diversity, as well as their specific needs and preferences. Although, PPB caries many advantages, it has also some disadvantages as stated above, which should be considered. Thus, the main goal of this study was to determine advantages and disadvantages of applying Participatory Plant Breeding (PPB).

MATERIALS AND METHODS

This study used a descriptive, correlation design. The statistical population comprised all plant breeders who worked at the Seed and Plant Improvement Institute (N=95). The sample size was determined by Krejcie and Morgan table (n=76). Breeders were studied through a simple randomized sampling method.

The major data collection instrument used in the present study was a questionnaire that consisted of four parts: Part one (18 items) was designed to identify the perception of breeders toward PB. These statements were measured on a five-point Likert scale with responses ranging from 1="strongly disagree" to 2="disagree", 3= "no opinion", 4="agree", and 5="strongly agree". In section 2 (12 items) was aimed to determine the advantages and part 3 (8 items) to measure disadvantages of PB. In these parts (parts two and three), all 20 items were measured on a ten-point scale that ranged from 0 = "low importance" to 10= "high importance". This scale was divided to three-point Likert scale (0-3.99 = "low importance", 4.00-6.99= "medium importance", 7.00-10= "high importance") during the analysis. Finally, demographic information of breeders was collected through the fourth part.

The instrument was assessed and confirmed for the content and face validity by a panel of agricultural extension and plant breeding experts. The instrument was pilot tested using a sample of breeders (N=30) at the research center in Kermanshah that was excluded from the population study. Next, to determine the reliability index of the instrument, Cornbach's alpha was calculated for Likert- type items of the questionnaire and it turned out to be somewhere in between 0.83-0.92.

The data were collected via applying the survey instrument. Twenty-three questionnaires (30.26%) out of 76 questionnaires were returned during four weeks. A follow-up reminder was used for non-respondents four weeks after initial survey (Miller & Smith, 1983). As a result of this second effort, an additional 46 questionnaires (60.52%) were received. Finally, 69 questionnaires (90.78%) were returned. Descriptive statistics such as frequencies, percentages, means, and standard deviation were used. Additionally, inferential statistics such as correlation coefficient was applied to determine the relationships among the variables. In addition, the stepwise linear regression was used to estimate the variance explanation of dependent variable by diverse independent variables. SPSS version 16 was used for data analysis.

RESULTS

Demographic characteristics of breeders

The average age of breeders was 42. About a quarter (22.4%) of them was 35 or younger and nearly half of them (55.2%) were between 36 and 45. The majority (59.2%) of respondents were male. Sixty-one percent of breeders had MSc degree and the remaining 39% had PhD degree. Most of them had studied breeding and biotechnology (69.7%) and others (30.3%) had studied related majors such as genetic, plant physiology, agronomy, and so on. The mean of respondent's job experience was more than 13 years (13.84). Concerning employment situation of breeders, a little more than one half (53.9%) had official or permanent job and others were contractual. A large number of breeders (86.8%) had participated in more than three training courses related to PB, and only 13.2% had participated in less than three training courses. Most of the breeders (59.2%) had a brief understanding of PPB, and only 18.4% of them were in high level of familiarity with PPB.

Perception of breeders toward using PPB

In general, the breeders tended to present positive view (between somewhat and agree level) toward PPB usage (Mean = 3.17; SD = 0.49) (see Table 1). In the questionnaire, breeders were asked to indicate their perception toward using PPB with 18 statements. Means and standard deviations for these 18 perception statements are represented in Table 1. A number of five out of 18 statements had a mean value close to four level of agreement. The highest means were related to the statement of "attention to the local and indigenous knowledge" (Mean=3.98, SD=0.8); "acceptance of new variety by farmers" (Mean=3.85, SD=0.93) and "strong relationship between farmers and breeders" (Mean=3.84 and SD=0.83). This allowed breeders to better understand the local farming conditions, the farmers' traditional ways of managing plant diversity, as well as their specific needs and preferences. Furthermore, PPB can empower groups, especially women or less well-off farmers that are traditionally left out of the development process. Compared to the Participatory Varietal Selection

Table 1
Mean, Standard Deviation and Breeders' Perception preferences towards Using PB (n=76)

Items	Mean	SD	Rank
Attention to local and indigenous knowledge	3.98	0.80	1
Acceptance of new variety by farmers	3.85	0.93	2
Strong relationship between farmers and breeders	3.84	0.83	3
Higher genetic diversity and more options for farmers	3.60	1.04	4
Using participatory breeding method toward sustainable agriculture	3.53	0.99	5
Higher acceptance of new released varieties	3.32	1.03	6
Improving farmers' life quality	3.30	1.03	7
Using local varieties in participatory breeding	3.27	1.04	8
Using drought tolerant plants in participatory breeding can improve water efficiency	3.19	1.11	9
Scientific value of participatory breeding is very notable in dry and marginal lands	3.17	1.05	10
Decrease in technical and economic efficiency could diminish farmers' attendance	3.10	1.01	11
The poorer the farmers, the lower their role in participatory breeding	3.07	1.06	12
Farmers have a major role in participatory breeding	3.05	1.00	13
Participatory breeding is comparable with other breeding programs in terms of scientific value	2.92	1.05	14
Participatory method is not suitable for the country at present time**	2.59	1.09	15
In all participatory programs farmer should be part of the program	2.52	1.31	16
No success will be achieved in participatory breeding without farmers co-operation	2.47	1.10	17
Participatory breeding is suitable for the region in which diversity will decrease pests' and diseases' attacks	2.35	0.77	18
Total (Sum of Means*)	57.12	18.2	

* Mean computed on a scale 1 = strongly disagree to 5 = strongly agree and could range from a low scale of 18 to high scale of 90 with the theoretical midpoint of 54.
** Reversed type: 5 = strongly disagree to 1 = strongly agree.

(PVS) where farmers are only involved in variety selection among a line's pre-determined group being field tested, PPB is found to have a higher empowerment effect. Eight statements had a mean value between 3.00 and 3.50, indicating that breeders had ''no opinion'' about using PPB. Moreover, three statements (14, 15 and 16) had a mean value close to three, which is 'no opinion' (see Table 1).

Advantages of using participatory breeding

Results indicated that, overall, breeders pinpointed the "medium importance" level of advantages of using PPB (Mean= 6.68, SD= 2.51). More specifically, breeders were asked to describe the advantages of using PPB through 12 statements. The means and standard deviations of 12 advantage statements are reported in Table 2. As it is perceived, four of statements had a mean value between 7 and 10, indicating "high importance". The highest mean was related to these three statement: "Ability to use in farms (on-farm)" (Mean= 8.15, SD= 2.16); "higher farmers' acceptance because of farmers cooperation" (Mean=7.53, SD=2.48) and "ability to show new varieties in different microclimates" (Mean=7.19, SD=2.26). There are four main activities where farmers can contribute: The farmers can share their knowledge and experiences, they can contribute in genetic materials; they are able to conduct trials; and finally, select and evaluate germplasm. A wide range of impacts were achieved through the use of participatory approaches. Participatory Plant Breeding (PPB) generally involves a greater and more complex degree of farmers' involvement due to their engagement in decision-making process in earlier and more fundamental stages of the variety development chain. PPB can have a large empowerment effect on participating farmers, when they are intimately involved in the programs from the early stages of the research design. In case of on-farm varietal selection, ideas from a variety of members of the community, not just selected members to participate in the breeding program, can be more easily incorporated upon identifying community needs and preferences. Other statements had the mean score between 4 and 6.99 indicating "Medium importance" of

Table 2
Mean, Standard Deviation and Rank of Advantages of PB (n=76)

Advantages	Mean*	SD	Rank
Using PB as on-farm	8.15	2.16	1
Higher acceptance among farmers because of farmers co-operation	7.53	2.48	2
Ability to show new varieties in different microclimates	7.19	2.26	3
Making farmers more capable to do farming by establishing connections with researchers	7.13	2.35	4
Applying a more demand driven method	6.93	2.68	5
Increasing usefulness and effectiveness of breeding	6.73	2.70	6
Selection of the varieties with appropriate production potential in different climatic conditions	6.72	2.44	7
Integrating local and new science	6.67	2.80	8
Participation of farmers in all plat breeding steps	6.14	2.65	9
Systematic record of farmers' knowledge	6.01	2.40	10
Protecting local germplasm	5.81	2.67	11
Paying more attention to small farmers	5.21	2.53	12
Total	6.68	2.51	

* Mean computed on a scale 0 = Low Importance to 10 = High Importance and could be categorized to a three-point scale: (0-3.99 = "low importance", 4.00-6.99= "Medium importance", 7.00-10= "High importance").

these PB advantages. The lowest mean value referred to the statement "paying more attention to small farmers" (Mean= 5.21, SD= 2.3) (Table 2).

Participatory breeding disadvantages

Breeders were asked to describe the disadvantages of the use of PPB using eight statements. Means and standard deviations of the statements are reported in Table 3. Looking at the table, the findings showed that the average of disadvantages items had a "high importance" concerning the use of PPB (Mean= 7.08, SD= 2.60). Half of the disadvantages had a mean value higher than seven, indicating the "high importance". The highest mean referred to "lack of enough relationship and coordination between different parts" (Mean= 8.35, SD= 2.21). The last four statements had the mean score between 4 and 6.99, indicating the "medium importance". The lowest mean value was related to the statement "no optimum conditions for testing the method in the field" (Mean= 6.30, SD= 2.57) (Table 3).

Determining the correlation between research variables and breeders' perception toward the use of PB

Pearson correlation coefficient was calculated to describe the relationships between research variables and breeders' perception toward PB usage (Table 4). There was a positive significant relationship between "levels of familiarity with PB", "advantages" and breeders' perception toward PPB usage. Moderate negative relationship ($r = -0.345$, $p<0.01$) was found between "disadvantages" and breeders' per-

Table 3
Mean, Standard Deviation and Rank of Disadvantages to use PB (n=76)

Disadvantages	Mean*	SD	Rank
Lack of enough relationship and coordination between different parts	8.35	2.21	1
Lack of team-working and participative behaviour among the farmers and researchers	7.56	2.60	2
Minor role of agricultural extension	7.25	2.58	3
Little farmers' knowledge about this method	7.22	2.49	4
Lack of suitable facilities for this method	6.68	2.74	5
Lack of proper environment for farmers' participation	6.65	2.58	6
Lack of appropriate laws and regulations	6.60	3.03	7
Lack of optimum situation for testing the method in the field	6.30	2.57	8
Total	7.08	2.60	

* Mean computed on a scale 0 = Low Importance to 10 = High Importance and could be categorized to a three-point scale: (0-3.99 = "low importance", 4.00-6.99= "Medium importance", 7.00-10= "High importance").

Table 4
Correlation between research variables and breeders' perception (n=76)

Variable	r	p-value	DCIC [1]
Age	0.17	0.137	-
Work experience	0.17	0.141	-
Number of passed training courses	0.10	0.352	-
Education level*	-0.16	0.155	-
Level of Familiarity with PB	0.34**	0.002	Moderate
PB Advantages	0.74**	0.001	Very high
PB Disadvantages	-0.34**	0.002	Moderate

*For this variable spearman (rho) correlation coefficient (rs) was used.
**P<0.01

Table 4
Stepwise regression of breeders' perception with regard to independent varibles (n = 76)

Variable	B	Beta	t	p-value
Constant	27.94	-	8.29	≤0.01
PB Advantages (x_1)	0.28	0.70	8.94	≤0.01
PB disadvantages (x_2)	0.17	-0.19	2.45	≤0.01

R= 0.761 R^2= 0.58 R_{Ad}=0.568 F= 50.32 P≤0.001 DW= 2.02
$Y=Constante + b_1(x_1)+ b_2(x_2)$
$Y= 27.94 + 0.28\ x_1 + 0.17\ x_2$

ception; however, no relationship was revealed between "age", "work experience", "number of passed training courses", "education level" and breeders' perception toward the use of PB. Overall, similar to the findings of Davis (1971), most measured relationship rates were between moderate and very strong levels (see Table 4).

Stepwise multiple regression of breeders' Perception and independent variables

Durbin-Watson's statistical value was calculated, and it was equal to 2.02, which indicated the possibility of using regression for this research (Moemeni & Ghayumi, 2007). Stepwise multiple regression analysis, as such, was used to determine the regressions' equation. Variables such as: "familiarity level with PB", "PB advantages" and "PB disadvantages" which had significant correlation with dependent variable were selected for the regression analysis. After three steps, only "PB advantages" and "PB disadvantages" remained in the equation. These variables explained 58% of the variance in breeders' perception toward the use of PB (see Table 5).

DISCUSSION

As it was illustrated earlier, varieties created by conventional breeding are beneficial for the farmers who have fertile lands and easy access to agricultural inputs and water. Therefore, small and poor farmers are not able to adopt these modern and efficient varieties, and as a result, their lifestyle is not expected to improve. Working with these small and farmers in breeding new varieties could help them to alleviate their problems (Ceccarelli et al., 2007; Murphy et al., 2005). Accordingly, the major goal of this study was to determine the advantages and disadvantages of Participatory Breeding system in Iran.

The results of this study indicated that most of the experts accentuate "attention to local knowledge" as the key of success in participatory breeding system. Farmers have improved and bred crops over last decades and therefore have valuable experience in that respect, which, unfortunately, has always been neglected. Consequently, collecting the data of farmer's local and indigenous knowledge and conducting research based on them is strongly recommended.

The findings of the research also demonstrated that on-farm trials and farmers 'acceptance are

[1] *Davis Correlation Intensity coefficient*

assumed as most important advantages of the participatory breeding. These results are in agreement with the study of Mustafa et al. (2005) who reported that farmers in critical situations and high stress environment do not accept varieties produced by conventional plant breeding, and according to his research, surprisingly, the farmers' acceptance rate was zero percent.

Additionally, this research showed that "lack of necessary and sufficient coordination between different divisions" and "the lack of existence of morality of participatory work among agriculturists and researchers" are the most crucial problems of participatory breeding. These results are in line with the study of Ceccarelli et al. (2000) who reported that the lack of cooperation between agricultural extension and education institutes is the main bottleneck of participatory programs. In order to achieve a successful participatory breeding program, cooperation of all parts in agriculture would be necessary. Furthermore, the cooperation of researchers and agriculturists and also agricultural extension and education organization and executive parts would be essential. In order to help farmers and breeders and to apply successful implementation of this method, cooperation of agricultural extension specialists looks vital.

Correlation analyses of the study suggested that there was a positive significant relationship between the levels of familiarity with PB, PB advantages, and breeders' perception toward PPB usage, and also, a negative relationship was found between PB disadvantages and breeders' perception. On the other hand, as participatory breeding compatibility increases, breeders' familiarity and addressing the aforementioned issues could enhance the acceptance rate of this method. Accordingly, it is proposed that more workshops, seminars and congresses are held on PPB in order to get more people acquainted with this method and its advantages.

At the end of the questionnaire, respondents' perceptions was asked about the use of participatory breeding and more than half of the breeders had a positive and favorable attitude towards utilizing participatory breeding. It is, then recommended that an official place should be dedicated for the implementation of these beneficial plans by the Ministry of Agriculture.

Ultimately, some more suggestions could be listed as below:

• Increasing the cooperation among breeders, farmers and extension agents at national and international level for better achievements of PPB project.

• Using farmer-researcher oriented systems for increasing the effectiveness of PPB projects is advised.

• Creating a powerful database of indigenous knowledge for documentation and access to valuable experience of farmers is recommended.

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