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Review

The potential and limitations of farmer participatory research in organic agriculture: A review

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Farmer participatory research (FPR) emerged in response to limitations of top-down Research and Development (R&D) approaches. The main purpose of this paper is to inspire and guide aspiring and new practitioners of participatory research and development (PR&D) to learn, reflect and constantly refine the way they work. The primary target users are field-based researchers involved in activities dealing with the interrelated issues of natural resource management, agriculture and rural livelihoods. They may have technical or social science backgrounds but share a common interest in drawing on the PR&D knowledge base. The paper is intended to enhance access to systematized information on field-tested PR&D concepts and practices among field practitioners and their organizations. This paper offers a conceptual model for participatory research projects that aim to improve the sustainability of organic agriculture.

Key words: Farmer participatory research, appropriate technology, agricultural research, on farm research, sustainability.

INTRODUCTION

Origin and emergence of farmer participatory research

Farmer participatory research emerged as a response to the generation of inappropriate technologies by scientists at research stations whose work was based on the transfer-of-technology model. Those working in this field began to develop a series of new research approaches that would result in technologies that would be beneficial to, and therefore adopted by, small farmers. The transfer-of-technology model was predominant in the 1950s and 1960s. The fact that small farmers did not adopt the technology packages developed at research stations led researchers to conclude that farmers were backward or ignorant, and that the key to success lay in creating a better extension service. Thus, the training and visit system (T&V) of Agricultural Extension was widely implemented. In the 1970s and early 1980s, non-adoption, still a problem, was attributed to constraints occurring at the farm level.

Farming systems research arose as a response, emphasizing research at the farm level to diminish constraints to the adoption of new technologies. It has received increased attention and recognition since the "Farmer First" (Chambers et al., 1989). Participatory technology development (Jiggins and De Zeeuw, 1992) concepts were introduced in the late 1980s. Finally, in the 1990s, some researchers came to believe that the problem was not the farmers, but the inappropriate technologies they were being encouraged to adopt. This marked the emergence and gradual evolution of farmer participatory research, an approach aimed at creating appropriate technology for small farmers (Chambers et al., 1989; Cramb, 2000) and for organic and biodynamic

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agriculture (Ponzio et al., 2013).

The concepts of "farmer participatory research" started to spread by the acknowledgement that the active participation of the final users of the research products to the research activity itself would have enhanced the efficiency of the identified technological solutions and facilitate their adoption, also enabling the farmers to become active proposers of key research objectives from their side, in line with their actual emerging needs (Lockeretz, 1987; Bachinger et al., 2000).

One key element of participation is an emphasis on developing the capacity of local people as an end in itself, as opposed to the purely mechanistic emphasis of participation as a means within the technology development flow that has often characterized research and extension programs. During the late 1980s and early 1990s, increasingly more field-based experiences emerged creating more space for methodological and institutional innovations for agricultural research and extension. Within these participatory approaches - as they became commonly known - a special emphasis was placed upon participation of local people and their communities, especially working with and through groups; and building upon the traditional or indigenous knowledge that they held (Chambers et al., 1989; Waters-Bayer, 1989; Haverkort et al., 1991).

Later on, with the onset of the innovative approaches of agro-ecology and rural sociology, a new "client-driven" concept was developed that requires decentralized technology development and devolves to farmers a high responsibility for adaptive testing (Ashby and Sperling, 1995). Nevertheless, consumers as well play a role in indirectly orientating agricultural research, as stated by (Guttman, 1978), being the primary beneficiaries of the research's products. Consumers demand more and healthier food, and they become aware of the negative externalities due to intensive agricultural and agro-processing practices. Evidence of this high attention by consumers to the way the food is actually produced is given by the fact that representatives of consumers associations actively participate to the works of the certification committees of the organic agriculture certification bodies, in order to closely monitor the conformity to the standards "from the field to the fork".

The challenge for development workers, researchers, and farmers is to design and use research methodologies that ensure the development and adoption of improved agricultural technologies to create sustainable agricultural production that will benefit the resource-poor farmers. Understanding the sustainability is the challenging question, with a continuous research for sustainable development which focuses on preserving or increasing the capacity of the systems being managed to produce desired benefits also in the future. Actor-oriented, integrative and participatory approaches (Cramb, 2000) are increasingly seen as a way to address the multiple and often conflicting social, environmental, and economic sustainability goals of different interest groups.

Education, research and extension in agriculture remain the vehicles to achieve sustainability in any modern food systems. The preparedness of future agriculturists requires a more holistic approach and this can be achieved through education reform in the college of agriculture through a promotion of innovative thinking and leadership (Borsari, 2012).

Education also serves to accentuate the need for policy change in the current management of our extremely centralized food systems and to foster transparency concerning information and regulation for anything concerned with food production and its distribution to markets and consumers (Borsari, 2011). Preservation of agrobiodiversity remains fundamental to any form of agriculture, while the mandate of lessening the dependence on non-renewable fossil-fuels to maintain production needs to shift toward more renewable energy sources (Borsari, 2012).

PARTICIPATORY APPROACHES TO AGRICULTURAL RESEARCH

Today, research in agriculture typically takes place under three modalities that in turn affect the choice of the physical site hosting the investigation activity (Figure 1): Basic research, applied research and on-farm research, this being principally executed within real operational farms (commercial farms). In the latter case, the researcher establishes a direct relationship with the farmer, which may occur at various levels of intensity: from a mere formal collaboration (the farmer limits himself to implement the experimental protocol) to a shared knowledge process to be developed through a full partnership: in this way, the farmer becomes totally involved in the phases of experimental design, assessment and discussion of the results.

Sutherland (1999) described four modes of participation which link farmers with researchers: (a) contractual, where the researcher is all-powerful; (b) consultative, where most of the key decisions are with the researcher but a certain emphasis is put on farmer consultation in problem identification and priority setting; (c) collaborative, when farmer and researcher exchange knowledge and share decision-making; (d) collegiate, where the farmer has greatest power, with the researcher responding to farmer specific requests of investigation.

About the quality of the researcher/farmer relationships, Okali et al. (1994) argued that "farmer participatory research, in principle, aims to operate at the interface between knowledge systems: it can be described as a people-centered process of purposeful and creative interplay between local individuals and communities on the one hand, with formal agricultural and research knowledge on the other - the collegiate interface”.

According to the authors, the knowledge systems at

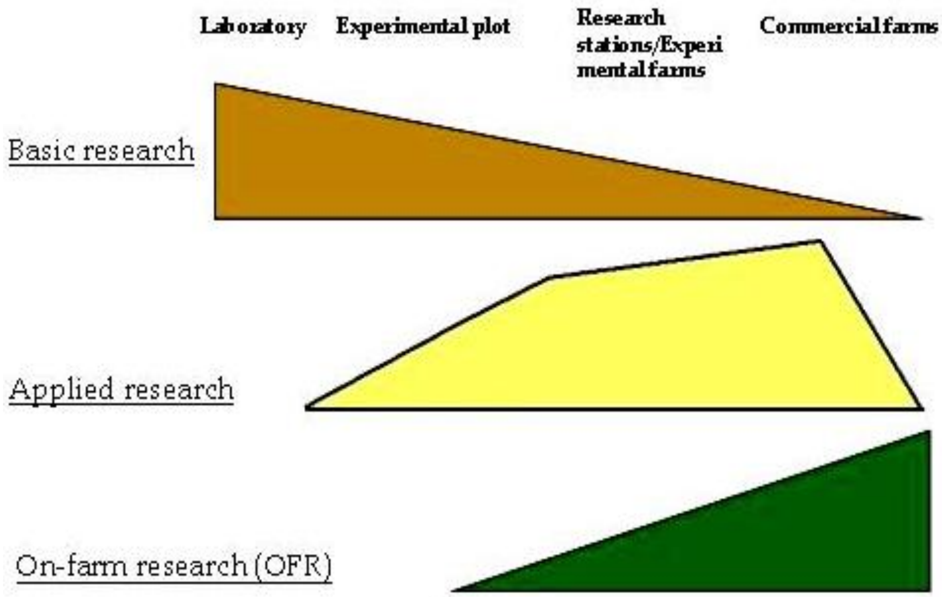

Figure 1. Agricultural research by site of operations.

stake are basically represented by the farmers' (local) knowledge on one hand and formal research (generic) knowledge on the other. Such knowledge systems may be therefore interfaced through 'creative interplay', so involving dialogue between different groups (local farmers and researchers): this dialogue will be respectful and serves to draw the two parties together in partnership ('collegiate interface'). While most of these assumptions may hold in optimal situations, however projects often face difficulties in linking ideas and actors in order to exemplify good practice (Sutherland, 1999).

Eksvard (2009) described the functions of a Participatory Learning and Action Research (PLAR) group in Sweden, composed by horticultural farmers, researchers and extensionists which was set up to test on-farm and evaluate the output of conventional research trials targeted at studying the best organic manuring options in organic horticulture. After pointing out the difficulties encountered inside the PLAR in harmonizing opinions and action plans among the farmers as well as between the groups of researchers and farmers, the author concludes that moving from conventional research approaches to trans-disciplinary approaches is not easy and strongly demands a common effort to relate the contextual knowledge of farmers to the abstract knowledge of scientists.

Sukkel et al. (2006) indicated in the Dutch Organic Farmers Network for Research, Development and Innovation (BIOM) a valid initiative for the improvement of the environmental and economic performance of the participating farmers. A wide range of practical experiments, resulting from specific bottlenecks highlighted by the network farmers, were carried out in 40 farms in cooperation with the agricultural scientists: the trials outputs mostly turned to increase yields, reduce labor input for hand-weeding and decrease nutrient surpluses. The authors strongly recommend the participatory approach to research through farmer's networks; however they state these tools also demand specific skills and attitudes from researchers, advisors and farmers.

Jones et al. (2006) reported about an on-farm research carried out to evaluate the performance of two soft wheat varieties in UK, by involving 14 organic farmers who grew the crops in their farms according to their standard cropping methodology. Measurements and laboratories analyses were carried out by the researchers but several field assessments were requested to the farmers (e.g. early and late crop groundcover, number and size of ears, straw length, etc.) who, however, showed a certain reticence in doing it. Farmers actually put forward the need for greater researcher-led assistance, which raised the issue whether the farmers well understood the concept of participatory approach and/or felt a poor ownership of the research project itself.

Yet the authors stated that new and valuable information was produced and both researchers and farmers considered useful the information on winter wheat variety performance under a range of organic systems; furthermore, farmers recognized the difficulty to reconcile the appearance of varieties in the field with their actual performance. However, authors recommended: (i) to spend more time in introducing the project and its objectives to the farmers; (ii) to discuss and develop the trial design in much closer link with them; (iii) to ascertain the full willingness and motivation of all the participants to

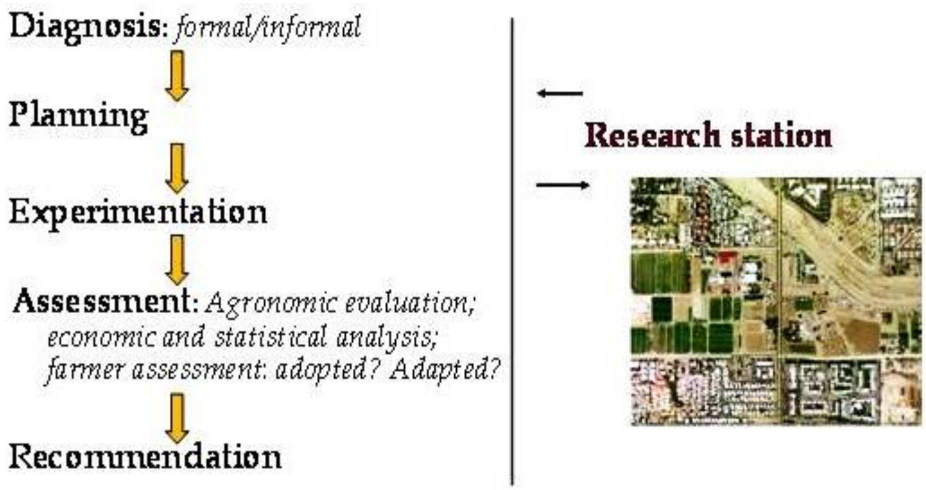

Figure 2. Typical stages for the execution of on-farm research: interactions with basic and applied research conducted inside laboratories and experimental stations are likely to occur (Tripp, 1991; Bachinger, 2000).

cooperate over the entire project (farmers and researchers).

The latter aspect was studied in depth by (Barreteau et al., 2010) who devised a conceptual analytic procedural framework to make participants' roles explicit in the implementation of different participatory research processes, thus preventing possible disappointment, reticence and project abandonment. The framework embraces three aspects: (i) the flow of information's among participants and the control over these flows for each step in the process; (ii) the timing and involvement of participants in the different steps of the research process; (iii) the modalities of communication among participants for each information flow (that is, bilaterally or as a group, mediated or face to face). The authors elaborated the framework from various experiences with participatory research; the framework is meant to be used from the very beginning of a participatory research process as a conceptual guide for researchers.

Basic, applied and on-farm research are interdependent and mixed approaches are very likely to occur; e.g. results from randomized block designs in other regions can be tested under local farming conditions (Figure 2) (Tripp, 1991; Bachinger et al., 2000).

According to the IAASTD report (McIntyre et al., 2009), participatory, collaborative methods and approaches have added value to the encounter between traditional/local knowledge actors and formal agricultural knowledge, science and technology (AKST) actors. Farmer-researcher groups in the Andes for instance brought together members of CIP (an international research institute) for the development and testing of measures and varieties to control late blight in potatoes, not only increasing productivity but also addressing issues for instance of inter-generational equity and the sustainability of soil management. Collaboration among knowledge actors in the commercialization and domestication of tree [and other] wild and semi wild species in participatory plant breeding (PPB) and in value-added processing are creating new value chains selling into both niche and mass markets. Other examples include efforts made in a number of countries to invite traditional/local knowledge actors into rural schools (e.g., Thailand) and universities (e.g., Peru, Costa Rica) as teachers and field trainers; to incorporate local AKST in the curricula and experiments run by village-based adult education and vocational training centers (e.g., India); and to expand opportunities for experiment-based, farmer-centered learning. Modern improved access to information and communication technologies (ICTs) shows large potential for extending and augmenting these developments.

Drinkwater (2002) put the emphasis on the relevance of studying "intact systems", in order to understand how a complex agroecosystem works as a whole in opposition to the typical factorial experiment approach, which aims at breaking down a complex system in order to isolate and study specific components and identify cause-effect relationships. The holistic participatory approach of on-farm research is fundamental because biodiversity performs key ecological services and if correctly assembled in time and space can lead to agroecosystems capable of sponsoring their own soil fertility, crop protection and productivity. There is consensus that at least some minimum number of species is essential for ecosystem functioning under constant conditions and that a larger number of species is probably essential for maintaining the stability of ecosystem processes in changing environments.

Research stages	*Stakeholders involved*
1. Livelihoods analysis and environmental assessment	Local farmers and soil scientists
2. Participatory nutrient budget, Semi-structured interviews and field visits	Representative farmers and key informants
3. Soil fertility feedback, discussions and Farm drives	Representative farmers, key informants and agricultural extension staff
4. Community meetings and Policy-Makers workshops	Community members, agricultural extension staff and policy makers
5. Participatory monitoring and evaluation of different soil nutrient management strategies	Agricultural extension staff with local communities

Figure 3. Stages of the methodological research framework followed by Dougill et al. (2002) to conduct interdisciplinary participatory research on land degradation in South Africa (redrawn from Dougill et al. (2002).

THE ROLE OF FARMERS AND RESEARCHERS IN ON-FARM RESEARCH AND PLANT BREEDING

Two different experimental approaches are discussed, both yielding meaningful results: i) field station trials, where simulated cropping systems are run in replicated plots, and ii) studies on whole agroecosystems in commercial farms. According to the author, an integrated research approach combining systems experiments with appropriately designed factorial experiments is highly recommended for a deep understanding of ecological processes in agricultural systems (Figure 2).

When approached from within, the investigated agroecosystem results more realistic in terms of scale of observation interconnected farming practices and management constraints to which the farmer is subjected: on-farm research therefore is likely to offer the opportunity to study it in a more integrated manner (Drinkwater, 2002). Through on-farm experiments farmers are given new skills, and confidence in problem-solving is enhanced (Bachinger et al., 2000).

Researches carried out by Dougill et al. (2002) in South-African small-scale farms allowed to study in depth the nutrients flow through the local agro-ecosystem and analyze in an interdisciplinary way the environmental, economic, political and social factors are influencing nutrient management, which is often the main cause behind the severe soil degradation occurring in the region.

The authors followed an original research methodological pathway (depicted in Figure 3) that started from holistic discussions on rural livelihoods, then turning to an in-depth participatory assessment of the key constraints likely to affect the natural resource management. It is stressed the importance to give to the farmers involved in the research process a good feedback on the research findings, that have to be discussed widely within local communities together with extension workers and, possibly, policy-makers.

Hard red spring wheat varieties were compared at six locations in organic farms in Minnesota and Nord Dakota, USA, over a three-year period. A basic scoring system was developed by researchers and farmers together. The farmers eventually indicated certain traits of the varieties under evaluation (e.g. grain yield, protein content, diseases resistance) as much more valuable than others (e.g. straw and stubble production, impact on succeeding crop), thus playing an active role in defining the variety prototype to be selected.

Ceccarelli and Grando (2007), researchers of the International Center for Agricultural Research in the Dry Areas (ICARDA), described a successful participatory plant breeding system (PPB), currently utilized in several Asian and North African countries. According to PPB, genetic variability is generated by the breeders in the experimental stations whereas the selection process of the most suitable varieties is carried out by the farmers and field extensionists in the farms (Figure 4).

In this way, the newly identified varieties are released faster with respect to the conventional breeding system, and most importantly the results are better adapted to the farmer’s needs and environment.

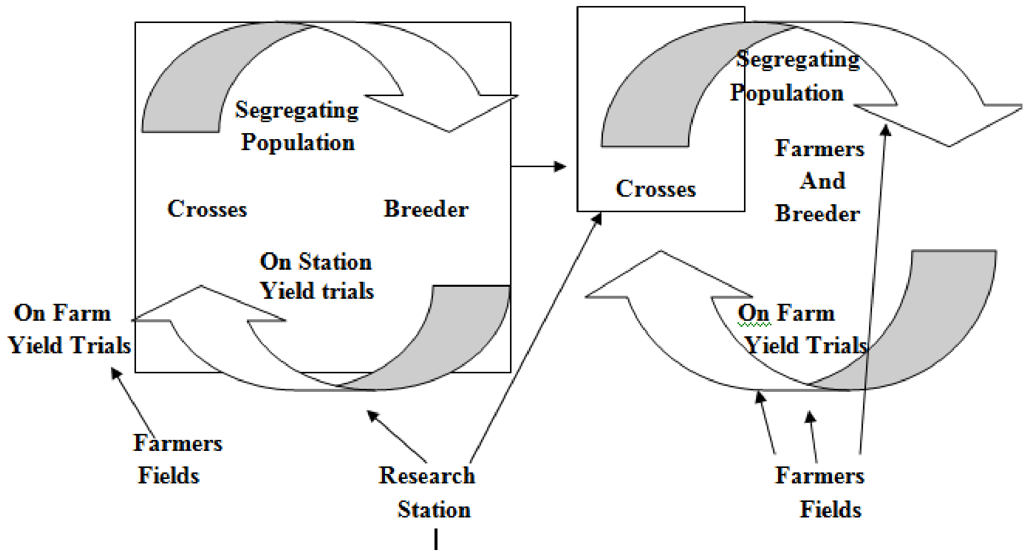

Figure 4. Conventional plant breeding is a cyclic process that takes place largely within one or more research stations (left) with the breeder making all decisions; decentralized participatory plant breeding is the same process, but takes place mostly in farmers' fields (right) and the decisions are taken jointly by farmers and breeders (redrawn from Ceccarelli and Grando, 2007).

The PPB advantages are particularly relevant in developing countries where multinational seed companies do not usually invest in big research programs because of low profitability and where many imported "improved" varieties are not in fact suitable for the local marginal cropping conditions. The authors conclude that on-farm breeding research, besides offering economic benefits, is characterized by psychological, moral and ethical added value stemming from the progressive empowerment of the agricultural communities, partners in the research activities.

A similar decentralized approach to assess new crop varieties was described by (Dorward et al., 2007) through the method of participatory varietal selection (PVS), conducted throughout Ghana in two agro-ecological zones, the Savannah and the Forest, by involving more than 2,000 small-scale farmers who evaluated, in several steps, in their own fields the performance of around 100 upland rice varieties, identified by the rice breeders. Once the farmers identified the most suitable varieties according to their own selection goals, the seeds of them were distributed to a small number of farmers, and the authors found that after a couple of years about 850 farmers in communities had already obtained the seeds from other farmers via informal mechanisms (gift, exchange or purchase), which gives the evidence of the good acceptance of the new seeds.

A semi-decentralized participatory approach was used by (Baidu-Forson, 1997) for the identification of the best farmers appreciated varieties of pearl millet (*Pennisetum glaucum L. Br.*). Fourteen varieties were comparatively tested in a research station and thirty farmers, from six villages across a north-south transect of western Niger, were selected to evaluate the varieties over two phases, by the support of structured questionnaires: the first, when the plants were at the reproductive stage (farmers visited the station and checked for the specific traits of millet plants and grain that were deemed by them more significant); the second, when post-harvest processing and food-quality traits of the grain were assessed at home, by the female sample farmers.

Unexpectedly for the author, the majority of farmers did not go for the highest productive varieties, rather they preferred the one characterized by early crop cycle; higher tillering capacity; large grain size and plant height > 2.5 m, all characteristics that offer higher probability of yield stability in the harsh environment of Sahel, thus indicating that farmer-led research objectives may somewhat differ from those of crop improvement programs devised by the scientists.

The participatory farmer approach to research is likely to present however negative facets, that have to be carefully assessed and addressed prior to begin the experiment. One aspect is about the difficulties to implement complex experimental designs and treatments due to the limited availability of time of the farmer, his/her lack of specific technical preparation and the structural inadequacy of the farm land: as a consequence, the potential of the analysis is drastically reduced (Selener, 2005).

The flexibility and the simplicity which are important traits of successful participatory research often lead to poor scientific validity of research results (Poudel et al., 2000; Wivstad and Natterlund, 2008).

Riley and Alexander (1997) reviewed the statistical methods utilized in sixty participatory on-farm research papers and emphasized the complexity of analyzing quantitative and qualitative sets of data often coming from heterogeneous disciplines, which demands a very sophisticated statistical approach. Nevertheless, from the review it emerges that statistical methodology was often poorly defined and inadequately used.

Typically, the more farmer participation that was involved, the more complex the underlying design structure however followed by poor statistical analysis. Confounding of effects and inadequate sampling were encountered frequently due to lack of clear design structure. The authors conclude that the kind of statistical methodology suitable for use in participatory on-farm trials is in fact available, and is capable to add high value to the quality of modern, unstructured multidisciplinary design and to the summary of collected data, whether they are quantitative or qualitative. However, such powerful methodology is not documented in a form easily used by non-statisticians, nor it is easily accessible.

The participatory process is indeed very time-consuming; it demands a lot of commitment and hard work both from the researchers and farmer cooperators. In addition, participatory on-farm research is cost sharing, which means that farmer cooperators are usually expected to do their research at their own expense, and this results hard for farmers above all in the context of developing countries, especially when they are subjected to the risk of negative financial return from their farming enterprise (Poudel et al., 2000).

Another hindrance is represented by a possible conflict of interests which can arise, if not properly prevented, between the scientist - more oriented to identify technical and innovative solution of general value, suitable for more farming environments and "communicable" to the international scientific community - and the farmer, much more interested in specific, locally-adapted, solutions for her/his farm (Sutherland, 1999; Lockeretz and Stopes, 2000).

In a sociological study (Eshuis and Stuiver, 2005), analyzing the process of "learning in context" in a sustainable dairy-farming project that involved the participation of farmers and scientists, emphasized how difficult was the interaction between the two groups because of the differences between the heterogeneous forms of farmers' knowledge and scientific knowledge. However, such differences were progressively reduced during recurrent phases of alternating conflict and alignment over the validity of knowledge, highlighting the relevance of such phases for progress in learning and generation of innovation.

As underlined by (Sutherland, 1999) effective on-farm research - blending formal and farmer-led approaches - principally requires a cross section of expertise. The end result is likely to be a compromise of methods and approaches to fulfill the expectations of all stakeholders: Over time, there will be possibly iteration from formal to informal and back again. As the level of understanding improves, there may be scope for the further development of methods to improve research efficiency.

CONCLUSION

Experimentation by farmers cannot entirely replace conventional scientific research and conventional scientific research cannot replace farmers' on-farm research. There is a need for a new educational and experimental approach that favors a "symbiotic relationship" between the two through a decision-making process in research, defining innovative farmers' and scientists' roles, and the style of the research to be conducted in the farms. The result is the incorporation of the most important and valuable aspects of each into a new system which will both benefit the small resource-poor farmer and contribute to the scientific knowledge base. The final objective is to improve the quality of life of indigenous communities at the agriculture through participatory innovation based on local resources in sustainable and diversified agroecosystems.

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Abbreviations: FPR, Farmer participatory research; **R&D**, research and development; **PR&D**, participatory research and development; T&V, training and visit system; **PLAR**, participatory learning and action research; **PVS**, participatory varietal selection; **IAASTD**, international assessment of agricultural knowledge, science and technology for development; **AKST**, agricultural knowledge, science and technology.

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